

## Scientometric Analysis of *Halyomorpha halys* (Stål, 1855) Research in Türkiye

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**ABSTRACT:** *Halyomorpha halys* (Stål, 1855) is a widespread invasive alien species on a global scale because of its broad geographic distribution, high dispersal capacity, and ability to cause economic damage to a wide range of agricultural crops. The species was initially documented in Istanbul, Türkiye in 2017 and has since expanded its distribution, particularly in the Black Sea Region. This study employed a scientometric approach to examine the temporal development, database distribution, and thematic orientation of the academic literature on *Halyomorpha halys* in Türkiye. Records retrieved from the National Thesis Center of the Council of Higher Education, DergiPark, Web of Science, and other indexes were systematically reviewed, duplicates were removed, and analyses were conducted using unique records only. The final dataset consisted of 75 studies, including 58 articles and 17 graduate theses. The findings showed that the literature is not limited to internationally indexed publications, but instead reflects a multi-layered structure supported by national journals, theses, and other indexed outputs. The temporal distribution revealed a marked acceleration in research production after 2023, indicating that this body of literature is evolving into a more established field of inquiry. The thematic analysis showed that the literature initially concentrated on first records, distribution, and status assessments, but later expanded toward more explanatory topics, including biological control, natural enemies, damage analysis, basic biology, physiology, and genetics. Taken together, the findings indicate that the Turkish literature on *H. halys* has moved beyond the early stage of invasive alien species reporting and has developed into a multidimensional research field shaped by applied ecology, biological control, and mechanism-oriented studies.

**KEYWORDS:** Biological control, Database, Dergipark, Invasive Alien Species, Multi-dimensional Research

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## INTRODUCTION

Biological invasions are increasingly regarded as a major environmental challenge because of their effects on biodiversity, community structure, and ecosystem functioning. Broad-scale assessments synthesizing the effects of invasive alien species on native biota have shown that these species can substantially alter local communities and ecosystem processes through competition, predation, herbivory, and habitat modification (Vilà et al., 2011). Likewise, invasive alien species affect not only species composition but also food webs, ecosystem services, and management costs; accordingly, biological invasions are regarded as not only an ecological but also an economic and governance-related problem (Simberloff et al., 2013). More recent studies on global economic losses have further demonstrated that invasive alien species impose very high costs on agriculture, forestry, human health, and infrastructure (Diagne et al., 2021). In general, this body of evidence indicates that when invasive alien species are transported beyond their native range, they may compete with native species, alter trophic interactions, and generate serious consequences for ecosystem services, as also emphasized in IPBES assessments (IPBES, 2023).

*Halyomorpha halys* (Stål, 1855), native to East Asia, stands out as an invasive pentatomid with high dispersal capacity and a broad host range. The species was first reported outside Asia in North America (Hoebeke & Carter, 2003) and subsequently spread rapidly across Europe, becoming a major threat to fruit, vegetable, and field crops (Haye et al., 2015; Leskey & Nielsen, 2018). This invasion pattern illustrates how invasive alien species can acquire both economic and ecological importance shortly after reaching new regions.

From a global biogeographic perspective, literature identifies *H. halys* as a typical example of a rapidly spreading invasive alien species. After moving beyond its native range, it was transported to new regions mainly through trade, transportation, and human mobility, and it established persistent populations wherever suitable climatic conditions and host resources were available (Haye et al., 2015). For this reason, *H. halys* is regarded not simply as an agricultural pest of a particular country, but as a species that warrants monitoring for biosecurity and invasive alien species management at the global scale (Leskey & Nielsen, 2018).

The invasion process in Europe followed a similarly rapid course. European studies show that the species has displayed an expanding distribution across the continent and has gained economic importance particularly in fruit production systems. At the same time, research has broadened from new country records to more detailed topics such as biological control and population dynamics (Haye et al., 2015). In this respect, the European experience shows that, once an invasive alien species is recorded in a new region, questions of management and suppression soon become prominent.

In Türkiye, the earliest academic assessments indicated that *H. halys* had emerged as an invasive alien species in the country. The first record from Istanbul was published by Çerçi and Koçak (2017), whereas the first records from Artvin and its surroundings were reported by Ak et al. (2019) and Günçan and Gümüş (2019). Subsequent studies showed that the species increased in population density particularly in the Black Sea Region and became more prominent at the regional scale; indeed, Ak et al. (2023) provided a detailed assessment of its distribution and population density in the Black Sea Region.

The regional distribution of the species within Türkiye has expanded over time. Çerçi (2021) reported the first record from the Aegean Region, while Kalkan and Satar (2023) identified the species as a new invasive insect for the Eastern Mediterranean Region. These records indicate that *H. halys* is not confined to a single subregion in Türkiye but can spread across different agroecological zones.

Taken together, the literature indicates that *H. halys* has followed a similar trajectory at global, European (Haye et al., 2015), and Turkish scales. First, new records and distribution patterns were documented; this was followed by growing attention to agricultural impacts and damage potential, and later by more advanced research topics including biological control, physiology, and ecological interactions (Ak et al., 2023). Thus, studies on *H. halys* do more than describe the distribution of a particular species; they also contribute to broader ecological questions concerning how invasive alien species establish, spread, and are managed in newly invaded regions.

Although the available studies have been conducted at relatively small spatial scales, the Turkish case still provides a useful perspective on how research on invasive alien species deepens and broadens over time. Studies on *H. halys* in Türkiye, while local in scope, point to a broader scientific question: how does knowledge production evolve from documenting the presence of an invasive alien species in a new region to understanding its impacts and investigating sustainable management options?

Accordingly, this study aims to scientometrically evaluate theses and articles produced on *Halyomorpha halys* in Türkiye using YÖKTez, DergiPark, Web of Science, and Google Scholar, and to reveal the temporal development, source structure, and thematic orientations of research on this species.

## **MATERIALS AND METHODS**

Scientometric analysis is widely used to examine the quantitative structure of scientific production within a specific research field by identifying publication trends, productive sources, thematic orientations, and knowledge structure (Borthakur & Singh, 2018; Mahmood & Dhakal, 2023). This study was designed as a descriptive bibliometric review to evaluate the academic literature on *Halyomorpha halys* in Türkiye from a scientometric perspective. Theses and articles published in the Turkish context on this species were systematically compiled, deduplicated, and thematically classified. This approach allows the identification of not only the quantitative size of a research field, but also its temporal development, document types, database visibility, and research trends.

A multiple-database approach was adopted for data collection. The data sources included the National Thesis Center of the Council of Higher Education (YÖKTez), DergiPark, Web of Science (WoS), and Google Scholar as a complementary search platform to ensure broader coverage and minimize database bias. This strategy was necessary because no single database fully covers all academic outputs on *H. halys* produced in Türkiye. WoS represents publications with international visibility, DergiPark covers studies published in national journals, YÖKTez includes graduate theses, and Google Scholar, provided supplementary information to some records located in other databases or with limited visibility.

The search strategy was based on the species' scientific name. The main search

terms used across databases were “*Halyomorpha halys*,” “brown marmorated stink bug,” and “kahverengi kokarca,” and the keywords “Turkey” and “Türkiye” were added to broaden the search's geographical scope. Search strings were adapted to the technical features of each database. After retrieval, records were exported, merged, and compiled into a common working file.

The dataset included theses and articles that directly focused on *H. halys*, were conducted in Türkiye, contained material from Türkiye, or explicitly referred to the Turkish context. Records that mentioned the species only indirectly, lacked a direct connection to Türkiye, had incomplete bibliographic information, or duplicated previously identified items were excluded. Different versions of the same publication across databases were compared using DOIs, titles, authors, and publication years. When the same article was found in both WoS and DergiPark, it was classified under WoS. One thesis known to have been completed but not yet available in the YÖKTez system was excluded from analysis in accordance with the principle of using only verifiable and accessible data.

For each record in the final dataset, publication year, document type, database source, title, author(s), journal or thesis information, DOI, and access link were recorded. In addition, all records were thematically classified into the following categories: first record/distribution/status; biological control/natural enemies/pathogens; damage/crop impact/economic threshold; traps-pheromones-monitoring; basic biology/physiology/genetics; chemical control; and other/indirect scope. This category includes studies indirectly related to *H. halys*, such as methodological or interdisciplinary approaches.

A descriptive scientometric approach was adopted for analysis. Publication distribution by year, number of records by database, thesis-to-article ratio, distribution of theses by degree level, the most productive journals and institutions, thematic distribution, and temporal change in themes were all assessed. The findings were presented and interpreted through tables and figures. This framework is consistent with the performance-analysis and knowledge-structure approaches commonly used in the scientometric literature (Darko et al., 2018; Belfiore et al., 2022; Heilig & Voß, 2014).

The main limitation of the method is the diversity in the scope of the databases, the differences in keyword-based search algorithms, and the variability of bibliographic standards in sources such as Google Scholar. Nevertheless, the use of multiple databases, a transparent deduplication procedure, and the analysis of unique records strengthened the methodological consistency and scope of the study.

## RESULTS

The dataset compiled from YÖKTez, DergiPark, Web of Science (WoS), and other indexes shows that a total of 75 studies have been produced on *Halyomorpha halys* in Türkiye. Of these, 58 were articles and 17 were graduate theses. In terms of source distribution, the literature consisted of 25 WoS records, 21 DergiPark records and 12 records from other indexes (Table 1). Taken together indicates that the field is shaped not only by internationally indexed publications, but also by national journals and graduate research.

In proportional terms, the largest share belonged to WoS (33%), followed by DergiPark (28%) and theses (23%) (Table 1). The distribution across sources shows that WoS reflects the international visibility of the field, whereas DergiPark and graduate theses reflect local, applied, and field-based knowledge production in Türkiye.

The distribution of graduate theses indicates that the field is becoming more diverse academically. Of the 17 theses, 13 were master's theses and 4 were doctoral dissertations, corresponding to 77% and 23%, respectively (Table 1). The relatively limited number of doctoral dissertations suggests that more advanced specialization is still developing, whereas master's theses appear to play a substantial role in early data generation and the applied dimension of research.

Among the 58 articles in the dataset, the number of authors per article ranged from 1 to 8, with a mean of 3.4. This suggests that the field is not based exclusively on single author work, but rather exhibits a modest yet clear pattern of collaboration.

**Table 1.** Distribution of studies on *Halyomorpha halys* in Türkiye

Document Type	Count	%	Subcategory / Index Category	Count	%
Thesis	17	23	Master's thesis	13	17
			Doctoral dissertation	4	5
Article	58	77	DergiPark article	21	28
			WoS article	25	33
			Other indexed article	12	16
Total number of publications				75	100

Among the journals in which these articles were published, Journal of the Heteroptera of Turkey and Journal of Plant Diseases and Protection ranked first, followed by Entomological News and Artvin Çoruh University Journal of Forestry Faculty (Table 2). This distribution indicates that the literature has developed both in journals with international visibility and in specialized journals based in Türkiye.

**Table 2.** Journals with the highest number of publications in the *Halyomorpha halys* literature in Türkiye

Journal Title	Number of Records
Journal of the Heteroptera of Turkey	4
Journal of Plant Diseases and Protection	4
Entomological News	3
Artvin Çoruh University Journal of Forestry Faculty	3
Acta Parasitologica	2
Black Sea Journal of Agriculture	2
Kahramanmaraş Sütçü İmam University Journal of Agriculture and Nature	2
Anadolu Journal of Agricultural Sciences	2
Black Sea Journal of Engineering and Science	2

The distribution of theses across universities shows that academic production is not evenly spread among institutions. On dokuz Mayıs University clearly stands out with 6 theses, followed by Fırat University with 3 theses, while each of the remaining universities is represented by 1 thesis (Table 3).

This pattern suggests that although *H. halys* research has become widespread in Türkiye, academic production is concentrated in particular institutional centers.

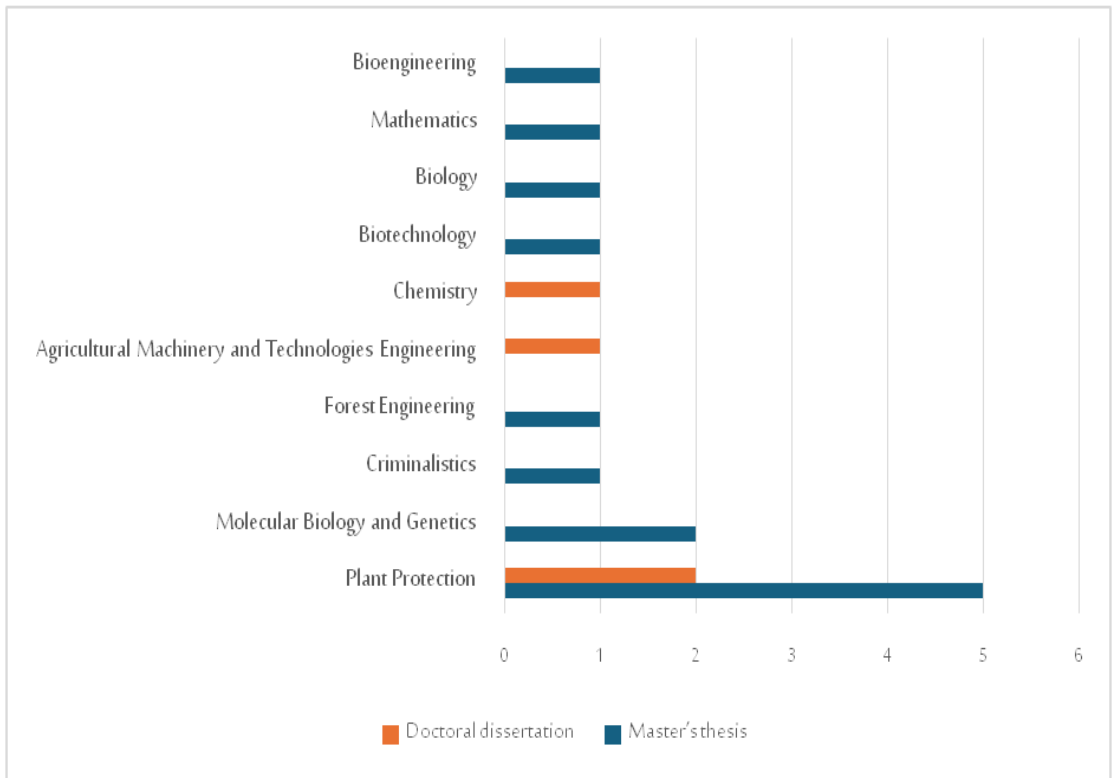
**Table 3.** Distribution of theses by university

University	Master's thesis	Doctoral dissertation	Total
Ondokuz Mayıs University	4	2	6
Fırat University	3	0	3
Artvin Çoruh University	1	0	1
Balıkesir University	1	0	1
Bursa Uludağ University	1	0	1
Gazi University	1	0	1
Giresun University	1	0	1
Recep Tayyip Erdoğan University	0	1	1
Tekirdağ Namık Kemal University	1	0	1
Tokat Gaziosmanpaşa University	1	0	1
<b>Total</b>	<b>13</b>	<b>4</b>	<b>17</b>

When theses were evaluated by institute and department, research was found to be concentrated primarily in Plant Protection. In the combined distribution, this field accounted for 7 theses, indicating that *H. halys* studies in Türkiye have been developed mainly within the framework of applied entomology and pest management (Fig. 1).

At the same time, the inclusion of fields such as Molecular Biology and Genetics, Biotechnology, Bioengineering, Chemistry, and Mathematics indicates that the research field is becoming increasingly interdisciplinary.

In particular, theses incorporating image processing, mathematical modelling, and climate-based distribution projections show that the literature is no longer limited to descriptive entomology, but is moving toward a more complex research framework shaped by data science, engineering, molecular biology, and quantitative modelling



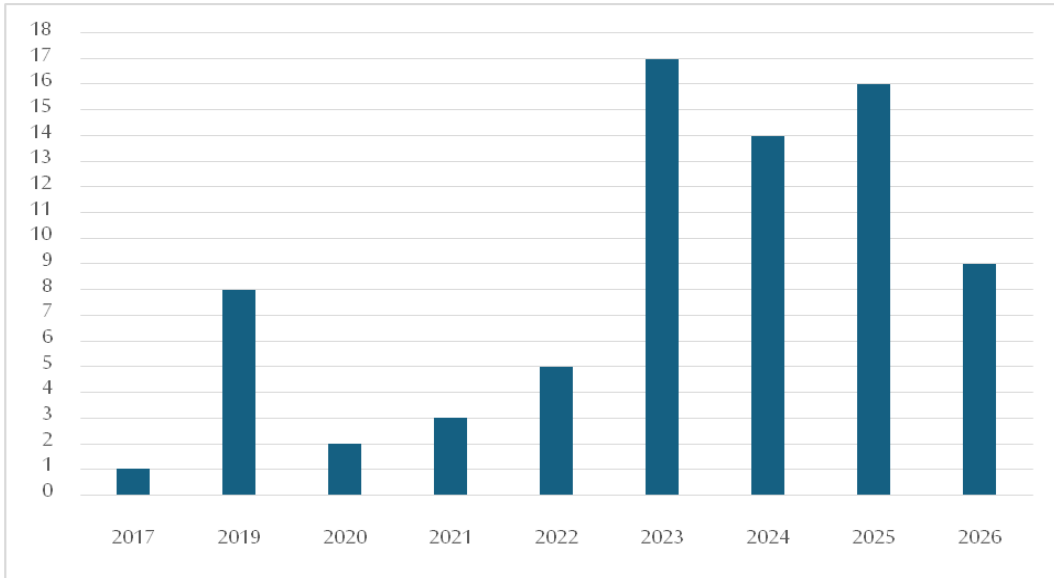
**Figure 1.** Comparative distribution of thesis types by department

When research production is considered over time, the literature on *Halyomorpha halys* in Türkiye accelerated markedly after 2019, with the main concentration occurring during 2023–2026 (Fig. 2, Table 4). The highest annual output was recorded in 2023, with 17 studies, followed by 2025, with 16 studies, and 2024, with 14 studies. The dataset also includes a single early record from 2017, representing the initial stage at which the species began to attract attention in Türkiye.

This temporal pattern indicates that *H. halys* was initially treated as a newly recorded invasive alien species, but that research interest increased rapidly as its agricultural damage potential and ecological impacts became more visible. The simultaneous rise in theses, DergiPark publications, and WoS-indexed articles after 2022 suggests that the topic has moved beyond scattered observations and has become an institutionalized, multi-source field of inquiry.

The yearly distribution of sources also clearly shows that the literature is not concentrated in a single database (Table 4). For example, DergiPark publications became particularly prominent in 2023, whereas WoS publications increased markedly in 2025 and 2026. These also made a regular contribution, especially between 2022 and 2025. This pattern suggests that the field first expanded at a national and applied level, and later strengthened its international visibility.

Fig. 2 shows that the number of studies produced on *Halyomorpha halys* in Türkiye increased substantially over time. Although the first record dates to 2017, the main period of acceleration occurred after 2023. Across the whole period, an average of approximately eight studies per year was produced.



**Figure 2.** Annual change in the total number of studies

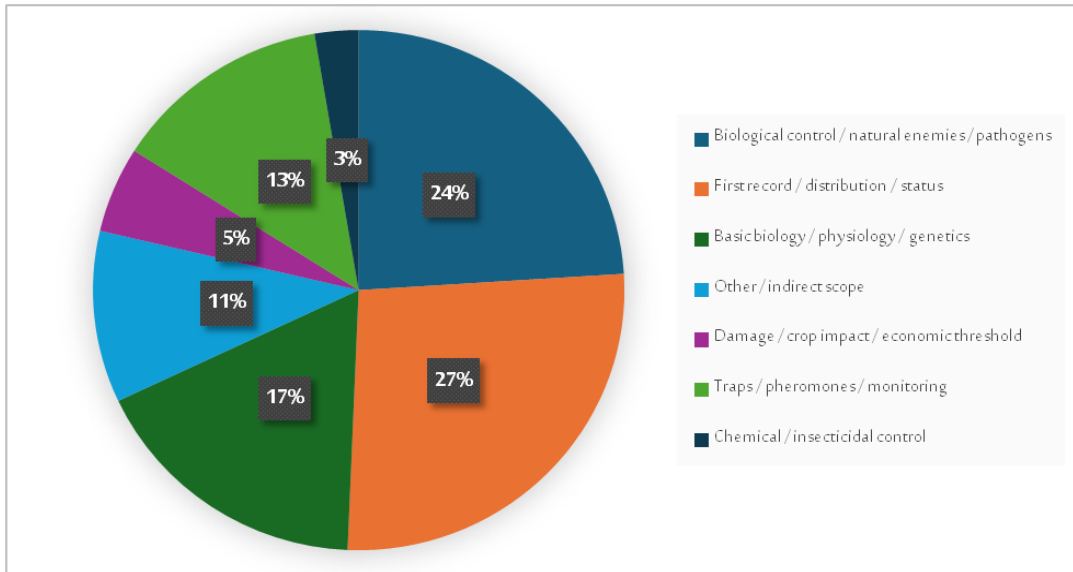
The database-based view of the dataset further shows that this numerical increase was accompanied by diversification of publication sources. National journals and theses primarily carried local and field-based knowledge production, whereas WoS publications represented research with greater visibility and broader international circulation (Table 4). Thus, the increase in publication output reflects not only quantitative growth but also institutional and publication-level diversification within the literature.

**Table 4.** Comparative distribution of theses and studies across databases by year

Year	Thesis	WoS	DergiPark	Other	Total
2017	0	0	0	1	1
2019	1	5	1	1	8
2020	0	1	1	0	2
2021	0	1	1	1	3
2022	3	0	2	0	5
2023	4	2	10	1	17
2024	3	1	4	6	14
2025	6	7	1	2	16
2026	0	8	1	0	9
<b>Total</b>	<b>17</b>	<b>25</b>	<b>21</b>	<b>12</b>	<b>75</b>

The thematic distribution shows that research on *Halyomorpha halys* in Türkiye is no longer limited to documenting first records and distribution. The fact that Biological control / natural enemies / pathogens accounted for the largest share (27%) demonstrates that sustainable management and biological suppression have become the most prominent themes in the field.

This was followed by First record / distribution / status (24%) and Basic biology / physiology / genetics (17%) (Fig. 3, Table 5). This distribution indicates that the literature has retained its focus on documenting invasion and monitoring spread, while also moving toward deeper lines of research aimed at understanding biological control and the functioning of the species itself. The substantial share of other / indirect scope (11%) further suggests that the field has expanded beyond classical entomological questions toward more indirect and interdisciplinary topics.



**Figure 3.** Thematic structure of the dataset

The distribution of themes across databases reinforces this transition. WoS publications were concentrated especially in Biological control / natural enemies / pathogens (12 records) and First record / distribution / status (6 records), suggesting that internationally visible studies have focused largely on documenting the invasion and developing management strategies. DergiPark publications, by contrast, showed a more balanced distribution across First record / distribution / status, Biological control / natural enemies / pathogens, and Traps / pheromones / monitoring, thereby highlighting local, applied, and field-based knowledge production. These were especially prominent in Basic biology / physiology / genetics and Other / indirect scope, indicating that graduate research has tended to engage more strongly with experimental, explanatory, and interdisciplinary topics. Publications in other indexes were most visible in First record / distribution / status and Basic biology / physiology / genetics, suggesting that they played a complementary role by expanding knowledge on both distribution and more analytical dimensions of the literature.

Taken together, these findings suggest that the Turkish case reflects not only the local research history of a single species, but also a broader shift commonly observed in invasive alien species research: a move from descriptive studies toward management- and mechanism-oriented approaches. The findings show that the *H. halys* literature has progressed from early-stage record-based studies to sustainable management approaches centered on biological control, and from there to deeper explanatory work involving physiology, genetics, and environmental interactions.

**Table 5.** Distribution of themes across databases

Theme	Thesis	WoS	DergiPark	Other	Total	Percentage
First record / distribution / status	1	6	6	5	18	24
Biological control / natural enemies / pathogens	3	12	5	0	20	27
Basic biology / physiology / genetics	5	2	1	5	13	17
Other / indirect scope	5	1	1	1	8	11
Damage / crop impact / economic threshold	0	1	3	0	4	5
Traps / pheromones / monitoring	2	3	4	1	10	13
Chemical / insecticidal control	1	0	1	0	2	3
<b>Total</b>	17	25	21	12	75	100

Taken together, the updated dataset shows that research on *Halyomorpha halys* remains largely concentrated in the Black Sea Region, especially around the hazelnut production system. Studies focusing on damage, product quality, economic thresholds, and phenological damage patterns clearly reflect this local context. At the same time, publications from WoS and other indexes demonstrate that the literature is no longer confined to damage and control, but has expanded toward deeper topics such as genetics, morphology, physiology, biological control, and environmental interactions.

Although most studies in Türkiye have mostly been conducted at a local scale and within specific production systems, they nonetheless reflect the broader developmental trajectory of invasive alien species research. The literature has progressed from documenting presence and spread, to increasing attention to damage and management, and finally to more mechanism-oriented investigations. In general, the findings show that the *H. halys* literature in Türkiye has become more extensive, more diverse in terms of source base, and more thematically developed. A key outcome of the analysis is that this field has moved beyond the early stage of invasive alien species reporting and has evolved into a broader body of work shaped by applied ecology, biological control, agricultural impact assessment, and physiological and molecular studies.

## DISCUSSION AND CONCLUSION

Research on *Halyomorpha halys* in Türkiye appears to follow a two-tiered structure. Theses provide a research setting in which new methods are tested, local data are generated, and mechanisms are examined in greater detail, whereas journal articles serve to place this production within a broader scientific debate, make thematic concentrations more visible, and accelerate the institutionalization of the field.

The presence of topics such as deep learning, mathematical modelling, climate projections, biochemistry and morphology in theses indicates the field is no longer confined to classical entomological description. By contrast, the prominence of biological

control and distribution in published articles suggests that the literature remains closely linked to applied management concerns. In this respect, theses tend to provide more experimental and exploratory contributions, whereas journal articles disseminate these findings more broadly within scientific literature.

The marked increase in studies after 2023 suggests that *H. halys* has ceased to be merely a newly recorded species in Türkiye and has instead become a central research subject because of its agricultural impacts and the need for management. This trend also parallels the broader European trajectory; indeed, the rapid expansion of *H. halys* in Europe transformed early record-based studies into research focused on management and suppression within a relatively short time (Haye et al., 2015). A similar transition can be observed in Türkiye, where early first-record and status studies were followed by research addressing population density and regional distribution. Articles documenting its distribution and abundance in the Black Sea Region (Ak et al., 2023), together with theses on the same regional context (Özen, 2022; Uluca, 2024), illustrate this shift clearly.

The thematic structure shows that the research field has broadened around two major axes: documenting the invasion and investigating management options. The continuing strength of studies on first records, distribution, and current status indicates that early-stage information remains important. At the same time, the growing number of publications on biological control, natural enemies, and pathogens shows that research is no longer limited to asking whether the species is present, but is increasingly concerned with how it may be ecologically suppressed.

This transition is clearly reflected both in parasitoid records reported in articles (Altanlar et al., 2023; Özdemir, 2023) and in applied and review studies focusing on biological control (Aşkın et al., 2022; Bekircan, 2026). This direction is also in line with the broader literature on sustainable pest management.

The findings further show that the literature has not remained restricted to applied control, but has also expanded into more mechanistic lines of inquiry. Studies on genetic diversity (Özdemir et al., 2025), publications focusing on entomopathogenic bacteria (Gençer et al., 2026), records of microsporidian pathogens (Eker et al., 2025), biology, morphology and anatomy (Aydın et al., 2024a, 2024b; Bal et al., 2025; Özgen et al., 2024) indicate that research in Türkiye has moved beyond descriptive entomology.

This shift is also evident in doctoral and master's research on physiology, biochemistry, ecology, morphology, monitoring, and modelling, including acetylcholinesterase inhibition (Akpınar, 2024), the biology, host use, and economic damage threshold of *Halyomorpha halys* in the Black Sea Region (Uluca, 2024), population status and damage in hazelnut orchards (Özen, 2022), the effects of different CO<sub>2</sub> levels on development and egg hatching (Kılınçtepe, 2025), feeding and reproductive behaviour under different diets (Şimşek, 2025), and the morphology and chemical components of scent glands (Aydın, 2025).

Graduate research has also addressed entomopathogenic bacteria (Demir, 2025), pheromone and trap efficiency (Güzel, 2022; Altanlar, 2023), distribution and host records in İstanbul (Muşdağı, 2023), insecticidal and biological control options (Karademir Coşkun, 2023; Karaduman, 2024), deep learning for damage detection (Gadalla, 2023), climate-based distribution projections (Alramadan, 2025), and mathematical modelling of parasitoid-based biocontrol effects on hazelnut yield

(Altunok, 2025). Taken together, these studies show that research on *Halyomorpha halys* in Türkiye has moved beyond descriptive entomology toward a broader explanatory framework focused on the species' performance, spread, and persistence under novel environmental conditions.

From a geographical and production-system perspective, the literature is strongly concentrated in the Black Sea Region, particularly within the hazelnut production system. Theses and articles focusing on damage in hazelnut, quality loss, economic thresholds, and phenology (Uluca, 2024; Özdemir et al., 2023b; Karakaya et al., 2024; Kan et al., 2024) show that the research agenda has been shaped directly by economic pressure.

This pattern reflects not only a local crop problem, but also a broader tendency: research on invasive alien species often intensifies in production systems where economic pressure is most acute. The Turkish case therefore indicates that research priorities are shaped not only by biological relevance, but also by socioeconomic consequences.

Studies on pheromones and traps form another prominent part of this applied orientation. Graduate theses evaluating the effectiveness of different trap types and pheromones (Güzel, 2022; Altanlar, 2023), together with field-based studies published as articles (Göktürk, 2020; Uluca & Ak, 2023), show that monitoring and suppression tools are being tested under Turkish conditions. This body of work is particularly important because it demonstrates how strongly invasive alien species management depends on local ecological context.

Sources affiliated with the Ministry of Agriculture and Forestry indicate that an integrated approach has been adopted against this species, combining monitoring, mass trapping, biotechnical practices, and biological control. This suggests that management of the species has become not only an academic concern but also an applied and institutionally recognized issue in agricultural governance (Türk Tarım, 2026).

Another important finding of this study is the necessity of a multiple-database approach. Had the assessment been based solely on WoS, a substantial portion of the applied studies published in national journals and many graduate theses would have remained invisible. By contrast, the present study shows that the real structure of the field can only be understood when WoS-indexed articles, DergiPark publications, YÖKTez records, and complementary studies from other indexes are considered together.

This result is important not only for *H. halys*, but also for the broader evaluation of invasive alien species literatures that develop at local and regional scales.

At the same time, the literature still contains important gaps. The relatively limited number of studies on chemical control may suggest that biological and sustainable approaches are gaining prominence, but it also indicates that long-term comparative data on control strategies remain insufficient.

Similarly, landscape ecology, nationwide distribution modelling, projections of spread under climate change, and standardized long-term monitoring studies are still scarce. These gaps suggest that, although the Turkish literature is strong in local and applied terms, it still requires broader spatial and more predictive ecological frameworks.

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