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Utilization of Black Soldier Fly (BSF) Maggots for Organic Waste Decomposition at the Mustika Ikhlas Integrated Waste Management Facility, Tigaraksa, Tangerang Regency

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Abstract: Waste management challenges in Tangerang have intensified due to the continuous increase in daily waste generation, which is not adequately supported by effective treatment systems, leading to waste accumulation and environmental degradation. This study aims to analyze the utilization of BSF maggots as a biological agent for organic waste decomposition at the Mustika Ikhlas Integrated Waste Management Facility (TPST), Tigaraksa. The research employed a descriptive qualitative approach conducted from November 2024 to June 2025. Data were collected through in-depth interviews with five key informants who were directly involved in organic waste management and BSF maggot cultivation activities. Data analysis was carried out using thematic analysis, encompassing data reduction, data display, and conclusion drawing. The findings reveal that the BSF maggot-based waste management process consists of several systematic stages, including organic waste sorting and collection, initial fermentation, controlled feeding, biodegradation by maggots, harvesting, utilization of harvested maggots as animal feed, and the reuse of residual media and larval exoskeletons as compost or soil enhancers. Based on field observations, 1 kg of adult BSF maggots can decompose approximately 10 kg of organic waste in 24 hours. Therefore, if the number of BSF maggots raised reaches 10 kg, the volume of organic waste that can be decomposed increases to approximately 100 kg in the same time period. These results indicate that BSF maggot utilization offers an effective, environmentally sustainable, and economically beneficial alternative for organic waste management. Furthermore, the study highlights the potential of BSF-based bioconversion as a scalable, integrated strategy for sustainable waste management in urban and peri-urban areas, particularly in regions with high organic waste generation. This research offers innovation in terms of research location (conducted at TPST Tigaraksa) and study focus (on the maggot cultivation process and its use in organic waste decomposition).

Keywords: BSF; Decomposition; Maggot; Organic Waste; Tanggerang.

Introduction

Ideal waste management is an essential component in efforts to create a clean, healthy, and sustainable environment. Waste generated by human activities, both household and industrial, should be managed systematically through reduction, segregation, treatment, and reuse to prevent negative impacts on the environment and public health. An effective waste management system is also expected to transform waste, particularly organic waste, into valuable, economically beneficial resources while simultaneously reducing the burden on final disposal sites (landfills). Thus, waste management should not be oriented solely toward disposal, but also toward environmentally friendly and sustainable utilization.

However, these ideal conditions have not yet been fully realized in many regions of Indonesia. In 2023, the national waste volume was reported to reach 36,113,922.58 tons, of which only 63.53% was properly managed, while the remaining 36.47% was not optimally managed and has the potential to continue increasing along with population growth [1]. This waste problem has become a complex environmental issue [2], affecting both urban and rural areas, including Tangerang Regency. Tangerang Regency is a densely populated area that serves as a buffer zone for the capital city of Jakarta and has experienced rapid growth in the industrial, trade, and service sectors [3]. These conditions have contributed to an increase in waste generation, which in 2022 was approximately 2,305 tons per day, dominated by organic waste, which is generally perceived as having low or no economic value [4–5].

The high volume of organic waste indicates a significant gap between the expected waste management conditions and the reality on the ground. On the one hand, organic waste has substantial potential for processing and reuse; on the other hand, much of it still accumulates, placing a heavy burden on existing waste management systems. The extensive industrial areas in Tangerang Regency, widely known as the "City of a Thousand Industries," further exacerbate waste accumulation if not accompanied by effective, sustainable treatment systems. If this condition persists, the risk of environmental pollution and a decline in community quality of life will continue to increase.

To address this imbalance, effective, environmentally friendly, and value-added solutions for organic waste management are urgently needed. One promising alternative is the utilization of Black Soldier Fly (BSF) maggots as agents for organic waste decomposition. BSF maggots are

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known to decompose up to 65–78% of the organic waste provided as feed daily [6], while producing by-products such as residue (kasgot) that can be used as organic fertilizer and maggots that serve as high-protein animal feed [7–8]. This method has been implemented at the Mustika Ikhlas Integrated Waste Management Facility (TPST) in Tigaraksa, Tangerang Regency, which combines technological approaches with community participation. Therefore, this study is important to examine the utilization of BSF maggots in decomposing organic waste at TPST Mustika Ikhlas, as well as to assess its potential development as a sustainable organic waste management model at the regency level. Therefore, the purpose of this study was to investigate the utilization of Black Soldier Fly (BSF) maggots to decompose organic waste into several by-products at the Mustika Ikhlas Integrated Waste Management Site (TPS) in Tigaraksa, Tangerang Regency.

Previous research has examined the use of Black Soldier Fly (BSF) maggots to decompose organic waste. These results indicate that BSF larvae, or maggots, have significant potential to accelerate organic waste decomposition and can be an environmentally friendly solution that is both economically and socially beneficial [9-13]. However, the majority of these studies still have limitations, such as not fully highlighting the technical process of maggot cultivation and the mechanisms for their utilization within an integrated waste management scheme. Some studies are also at the household scale and have not addressed actual implementation at processing facilities such as TPSTs. Therefore, this study offers innovations in terms of the research location (conducted at the Tigaraksa TPST, one of the organic waste processing sites at the Regency level) and the study aspects (focusing on the maggot cultivation process and their utilization in the organic waste decomposition process).

Research Methods

This study was conducted from November 2024 to June 2025 at the Integrated Waste Management Facility (Tempat Pengelolaan Sampah Terpadu/TPST) located in the Mustika Ikhlas Residential Area, Tigaraksa District, Tangerang Regency. The research site was selected due to the high volume of organic waste generated by households and traditional markets, which has not yet been optimally managed. This research employed a descriptive qualitative approach aimed at understanding the utilization of Black Soldier Fly (BSF) maggots in decomposing organic waste at the TPST in Tigaraksa, Tangerang Regency.

The research participants were five managers and employees of TPST Mustika Ikhlas. A purposive sampling technique was applied, in which participants were selected based on specific criteria [14], namely individuals who were directly involved in waste management activities and the cultivation of BSF maggots. The research instruments included observation sheets, interview guidelines, and documentation. The data collected covered organic waste management activities, the feeding process of organic waste to BSF maggots, and the utilization of BSF maggots.

Data collection methods included observation, semi-structured interviews, and documentation. Observations were conducted to monitor the process of organic waste decomposition by BSF maggots, including maggot behavior during waste degradation, the time required for the decomposition process, and physical changes in the waste throughout the process. Semi-structured interviews were carried out to obtain information regarding organic waste management practices, the potential utilization of BSF maggots, and challenges encountered during implementation. Documentation was conducted through photographs, video recordings, and field notes to support the results of observations and interviews. Data validation tests were conducted using data source triangulation techniques (interviews, observations, and documentation). The aim of this technique was to explore the truth of the information obtained by comparing data from interviews with sources, field observations, and documentation [15].

The research stages involved periodic monitoring of the process of utilizing BSF maggots in decomposing organic waste. Monitoring was conducted by recording changes in waste volume and weight, the level of decomposition, and the reduction in waste mass at specific time intervals. The collected data included the efficiency of organic waste decomposition by BSF maggots, changes in the physical and chemical properties of the waste, and the production of residues or compost generated. All observation results and documentation were recorded in field notebooks and documented in photographs or videos.

The research data were analyzed using descriptive qualitative methods to understand the process of BSF maggot utilization in organic waste management. The data analysis techniques referred to the Miles and Huberman model, an interactive analysis model consisting of three main stages: data reduction, data display, and conclusion drawing [16]. (a) Data reduction involved selecting, simplifying, and focusing raw data obtained in the field. Data from interviews, observations, and documentation were selected and categorized based on their relevance to the research focus, namely BSF maggot cultivation and their utilization in organic waste decomposition at TPST Mustika Ikhlas; (b) Following data reduction, the next stage was data presentation in the form of descriptive narratives. Data were organized and synthesized to facilitate the researcher's understanding of general patterns, relationships, and emerging themes; (c) The final stage of data analysis was conclusion drawing and verification. Conclusions were formulated based on the presented data and subsequently verified to ensure their validity and consistency. The resulting conclusions are expected to address the research questions and comprehensively describe the cultivation and utilization of BSF maggots in organic waste management.

Results and Discussion

Maggot BSF is utilized for the decomposition of organic waste and as animal feed at the Integrated Waste Management Facility (Tempat Pengelolaan Sampah Terpadu/TPST) Mustika Ikhlas, Tigaraksa District, Tangerang Regency. The stages of maggot BSF utilization include the collection and sorting of organic waste, fermentation of organic waste, feeding of maggot BSF, decomposition of organic waste by maggot BSF, harvesting of maggot BSF, utilization of maggot as animal feed, and utilization of residual media from the decomposition process. Figure 1 shows the flow diagram of maggot BSF utilization at the Integrated Waste Management Facility

(TPST) located in Mustika Ikhlas Housing Complex, Tigaraksa District, Tangerang Regency.
The following section provides a detailed explanation of each stage of maggot Black Soldier Fly (BSF) utilization at the Integrated Waste Management Facility (TPST) Mustika Ikhlas, Tigaraksa District, Tangerang Regency:

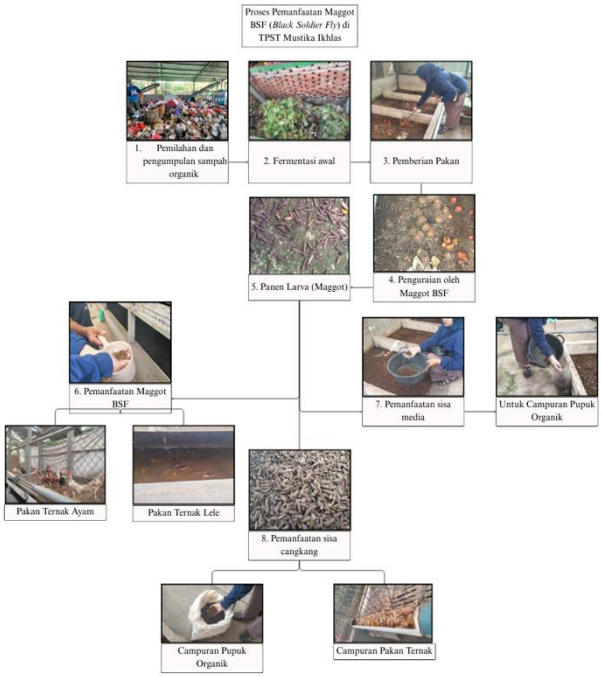

Figure 1. Flowchart of BSF Maggot Utilization at the Mustika Ikhlas TPST

Collection and Sorting of Organic Waste

Waste at TPST Mustika Ikhlas, Tigaraksa District, Tangerang Regency, is obtained from various sources, including traditional markets, households, and other sources. The waste is initially a mixture of organic and inorganic materials; therefore, a sorting process is required. This sorting stage is crucial to ensure that only organic waste enters the maggot cultivation media, as the presence of inorganic waste (such as glass, plastic, or metal) can interfere with BSF maggot growth and degrade decomposition. Sorting household waste before it enters the BSF process can significantly reduce waste accumulation and maintain the quality of cultivation media. Thus, waste sorting is a fundamental stage to ensure the cultivation process runs optimally. The waste collection process is carried out routinely to ensure the continuous availability of sufficient feed material for the maggots.

The waste sorting process at TPST Mustika Ikhlas is still conducted manually by workers (Figure 2). At this stage, organic waste is separated for further processing, either mechanically through composting or bioconverted with BSF maggots. Meanwhile, inorganic waste, such as plastic, bottles, and cans, is sorted by type and collected in sacks for sale as recyclable materials. Residual waste that has no economic value or cannot be further processed is ultimately disposed of at the final disposal site (Tempat Pembuangan Akhir/TPA).

Figure 2. Collection and Sorting of Organic Waste

Organic Waste Fermentation

The separated organic waste is then fermented, or left to stand for several days to soften its texture (Figure 3). Another alternative is to chop the waste into small pieces, making it easier for the BSF maggots to consume. This step helps speed up the decomposition process and increase decomposition efficiency. As explained by YF (an employee at the Mustika Ikhlas Landfill), *"...Usually, I'm only tasked with feeding the maggots, ma'am. Before feeding them, I can feed them soft vegetables or food waste directly. But if there's anything that's still hard, I usually let it sit first, or if I prefer to eat it directly, I cut it up myself and then feed it to the maggots*." (Interview with YF, June 30, 2025). Fruit peel fermentation increases the protein content of BSF larvae consuming the medium [17], as fermentation improves nutritional quality and suppresses pathogenic microbes. In other words, organic waste fermentation plays a strategic role in increasing the nutritional value of larval feed.

Figure 3. Organic Waste Fermentation

Feeding BSF Maggots

After fermentation, soft-textured organic waste is fed to BSF maggots as the primary food source (Figure 4). This is done directly into the rearing medium, with the amount adjusted to prevent excessive maggot growth and anaerobic conditions. BSF maggots then actively consume and decompose the waste. Maggot feeding is carried out in stages, adjusting humidity and feed quantity to ensure optimal larval growth. Waste composition and feeding rate directly influence maggot larval growth and waste reduction rates [18]. Proper feeding management will maximize larval growth and bioconversion effectiveness.

Figure 4. Feeding BSF Maggots

Waste Decomposition by BSF Maggots

In approximately 1 day, BSF maggots can decompose large amounts of organic waste (Figure 5). This decomposition capacity makes BSF maggots a potential alternative solution for organic waste management, especially in environments that generate high volumes of waste.

In the larval stage, BSF maggots exhibit a high capacity to consume organic waste. Based on field observations, 1 kg of adult BSF maggots can decompose approximately 10 kg of organic waste in 24 hours. Therefore, if the number of BSF maggots raised reaches 10 kg, the volume of organic waste that can be decomposed increases to approximately 100 kg in the same time period. This is reinforced by the statement by the Head of the Mustika Ikhlas Wastewater Treatment Plant (TPST) Management, SP, as follows: "*...Adult maggots have a very high consumption rate. Approximately 1 kg of maggots can decompose approximately 10 kg of organic waste. If 10 kg of maggots are available, approximately 100 kg of organic waste can be decomposed in one day. This process is much faster than using machines, which can take weeks*." (Interview with SP, July 5, 2025). This high efficiency confirms the role of BSF maggots as a highly potent bioconversion agent in organic waste management. A recapitulation of the decomposition of organic waste by maggots is shown in Table 1.

This finding aligns with research findings using a feed combination of 30% food waste and 70% vegetables with a feeding rate of 35 mg/larva/day, which resulted in a waste reduction rate of up to 81.98%. These results demonstrate that the quality and composition of the waste are crucial for the success of the bioconversion process, not just the number of larvae used [18].

In an urban context, BSF larvae have been reported to decompose up to 47.75% of urban organic waste, with a consumption rate of 26.15 g of waste per gram of maggots [19]. In addition to contributing to waste volume reduction, this process also produces byproducts in the form of compost and liquid organic fertilizer, which have added economic value. Furthermore, the bioconversion efficiency of domestic waste is reportedly higher than that of palm oil mill solid waste (decanter solids) [20]. The domestic waste reduction rate reached 76.5%, while the decanter solids reduction rate was only 32.6%. This difference indicates that the waste's physical and chemical characteristics significantly influence the success of the decomposition process.

Table 1. Recapitulation of organic waste decomposition by BSF Maggots We

Maggots Weight	Volume of organic waste decomposed	Time
1 kg	10 kg	24 hours

In addition to waste type, bioconversion efficiency is influenced by several other factors, including humidity, substrate type, and environmental conditions [21]. The zero-waste principle is emphasized in the BSF bioconversion system, as all products produced, including maggots, frass, and other residues, can be reused, resulting in no waste. Based on this comparison, it can be concluded that the research results at the Mustika Ikhlas TPST align with those of previous studies. Although the levels of waste reduction varied, the trend shown was relatively consistent: BSF maggots have a very high capacity to reduce organic waste volume while producing value-added products. This strengthens BSF's position as an environmentally friendly, cost-effective organic waste management solution in Indonesia.

Figure 5. Waste Decomposition by BSF Maggots

BSF Maggot Harvesting

Maggots that have reached the prepupa stage can be harvested for further use. Maggots are usually harvested at 14–18 days old, when their protein and fat content is still high. Harvesting during the larval stage produces biomass with a crude protein content of up to 40% and a fat content of 25%, making it highly potential as a feed ingredient [22]. Timely harvesting is key to achieving the best nutritional quality. Part of the harvest is reused in the breeding cycle, while the remainder is used as a protein-rich source of animal feed.

Animal Feed

BSF maggots at the Mustika Ikhlas Landfill in Tigaraksa District are used as supplementary feed for farmed chickens and catfish (Figure 5). Managers provide livestock feed composed of approximately 80% pellets and 20% BSF maggots as an additional protein source. The high protein content of BSF maggots helps improve livestock growth and quality, allowing managers to reduce reliance on relatively expensive commercial feed.

Managers utilize harvested maggots directly as feed for fish, chickens, and other poultry. Maggots cultivated in various organic media produce biomass with a high protein content, comparable to that of fish meal [23]. Many farmers utilize BSF maggots in the form of larval meal as an alternative animal feed source. The protein content of dry maggots reaches 40–48% with a relatively high fat content, making BSF maggots a potential substitute for fish meal, which is currently widely used in the fisheries and poultry industries [24]. This practice aligns with activities at the Mustika Ikhlas TPST, where managers harvest some of the maggots for use as supplementary feed for chickens and catfish, thereby reducing commercial feed costs.

Figure 6. Providing BSF Maggots as Feed for Chickens and Catfish

Utilization of Media Residues

The utilization of BSF maggot by-products at the Mustika Ikhlas Landfill (TPST) is as animal feed and organic fertilizer. The remaining media, or residue from BSF maggot activity, in the form of manure or frass, is used as organic fertilizer (Figure 7). The nutrient content of frass supports plant growth, making it a valuable by-product. This practice not only reduces organic waste but also adds economic value and supports the zero-waste principle. One example is the use of frass (larval manure and media residue).

The use of frass (manure and larval media residue) as an organic fertiliser has been shown to positively impact plant growth. Research results show that applying frass at the optimal dose (125 g/plant) can increase the growth and yield of pagoda mustard greens [25]. These results align with field observations, where residue from maggot activity is reused as organic fertilizer for surrounding plants. BSF frass is able to surpass the effectiveness of traditional fertilizers, both NPK and manure, in increasing vegetative growth and seedling biomass [26]. This indicates that frass can be a more environmentally friendly and economical fertilizer alternative, especially in areas where chemical fertilizers are difficult to obtain. BSF frass contains macronutrients such as nitrogen, phosphorus, and potassium, as well as microorganisms that support soil fertility [27]. However, the stability of frass and its interaction with the soil environment still require further research for more optimal utilization. Frass not only improves soil fertility but also stimulates the formation of mycorrhizae in tomato plants [28]. The presence of mycorrhizae strengthens phosphorus absorption and provides additional protection against plant diseases. This means that frass is not just a fertilizer, but also acts as a biofertilizer that supports sustainable agriculture. Thus, the results of this study strengthen the evidence that the BSF cycle provides dual benefits. Not only can it significantly reduce the volume of organic waste, but it also produces valuable byproducts that are environmentally friendly and support sustainable agricultural and livestock systems.

Figure 7. Collection of Frass or Kasgot (Maggot Waste)

Utilizing Remaining Shells

Besides residue, remaining pupa shells can also be further processed. These shells are generally used as a compost mix or as an additive in feed formulations, as they still contain beneficial nutrients (Figure 8). This way, no part of the BSF maggot cycle is wasted. As explained by SP, a resource person: "*...Actually, BSF maggots are very beneficial, ma'am, to the point that nothing is wasted at all. The maggots themselves can decompose organic waste, reducing air pollution and eliminating odors. Once the maggots have finished decomposing the waste, the residue can be used as a mixture for organic fertilizer. After they hatch from pupae into flies, their shells can be used as a compost mix or as a mixture for chicken feed here*." (SP Interview, June 30, 2025).

The shells or exuviae left behind by larvae when they pupate still hold potential for utilization. BSF pupa shells can be extracted to produce chitosan, which has the potential to be used in health products such as hand sanitizer [29]. Thus, shell waste, which was previously considered useless, actually has the opportunity for new, economically valuable uses.

Figure 8. Pupa Shells and Pupa Shell Compost Mixture

Field research at the Mustika Ikhlas Landfill (TPST) shows that the use of BSF maggots is not only a technical solution for decomposing organic waste, but also has broad implications for implementing zero-waste principles and strengthening the local economy.

Environmentally, this method significantly reduces the potential for pollution. According to a Life Cycle Assessment (LCA) study published in Environmental Science and Pollution Research (2024), waste processing using BSF maggots produces significantly lower carbon emissions than traditional methods such as landfilling or composting. In fact, in some scenarios, the BSF system was able to record negative carbon emissions, meaning the

process actually contributes to reducing the accumulation of greenhouse gases. These findings align with field conditions, where the use of BSF maggots is able to decompose organic waste quickly, eliminating the production of pungent odors or leachate that could potentially pollute the surrounding environment. Maggots can decompose up to 70–80% of organic waste in a short time [30]. This reduction in waste volume means less waste ends up in landfills, thereby reducing the risk of water pollution and foul odors.

Economically, maggot cultivation presents promising business prospects. Organic liquid waste processing with BSF maggots is financially feasible, with a positive Net Present Value (NPV), a Benefit-Cost (B/C) ratio above 1, and an Internal Rate of Return (IRR) higher than the discount rate [31]. In fact, the payback period is relatively short, around four years. This means that investing in maggot cultivation is not only profitable but also has a relatively low financial risk, especially if managed well. Maggot cultivation businesses can absorb hundreds of tons of organic waste per year while producing economically valuable derivative products, such as animal feed and organic fertilizer [32]. This finding is relevant to practices at the Mustika Ikhlas TPST, where frass residue is used as fertilizer, while some maggots are used as supplementary feed for chickens and catfish. Thus, this system not only minimises waste but also generates new economic resources. Utilizing organic waste through maggots also opens up opportunities for local agriculture. Agricultural waste previously considered worthless can be processed into poultry feed using BSF [33]. Thus, the concept of zero-waste agriculture can be implemented, where agricultural waste is fully utilized and returned to the production chain as value-added feed. This practice is relevant to the conditions at the Mustika Ikhlas Landfill, where the cultivation residue (frass) is used as fertilizer, while the maggots are used as feed for catfish and chickens.

From a socio-economic perspective, the success of BSF cultivation is also closely linked to community participation. The application of BSF technology in urban areas not only strengthens food security but also strengthens collaboration among residents [34]. Residents are directly involved in the waste management process, gaining economic benefits from the by-products, while maintaining a clean environment.

Overall, the combination of reduced environmental emissions and economic benefits demonstrates that BSF maggot cultivation has the potential to become a model for sustainable organic waste management. The application of BSF maggots at the Mustika Ikhlas Landfill reflects a waste management model that integrates ecological and economic aspects. This system not only reduces waste generation and environmental impacts but also opens up business opportunities and strengthens local economic independence.

Conclusion

The process of utilizing BSF maggots at the Mustika Ikhlas Landfill is carried out through several stages including waste sorting and organic waste collection, fermentation or initial processing, feeding, decomposition by BSF maggots, BSF maggot harvesting, animal feed, utilization of remaining media, and utilization of remaining shells. The results show that BSF maggots play a significant role in decomposing organic waste, with 1 kg of maggots decomposing approximately 10 kg of waste in 24 hours. In addition, maggots are used as high-value animal feed, while frass and pupa shells are used as fertilizer and compost materials. Thus, BSF maggot cultivation at the Mustika Ikhlas Landfill not only reduces waste volume, but also produces derivative products that are economical, environmentally friendly, and support the principle of zero waste and strengthen the local economy. The results of this study suggest the potential of BSF-based bioconversion as a scalable, integrated strategy for sustainable waste management in urban and peri-urban areas, especially in areas with high organic waste generation. Recommendation from this study: Further studies are needed to examine the potential of frass as an organic fertilizer by testing its effectiveness on various types of plants. In addition, research on the diversification of maggot-derived products, such as larval oil and protein extracts, should be expanded to enhance their economic value. Measuring the effectiveness of maggots in decomposing organic waste is also important to obtain more comprehensive data on their contribution to sustainable waste management.

Author's Contribution

This research is the result of collaborative contributions from all authors. Q. Mukhoyyaroh: contributed to the research concept and design, field data collection, data analysis, and drafting of the article. L.S. Nugraheni: contributed to research implementation assistance, data validation, and manuscript review and editing. All authors participated in the discussion of the research findings, provided substantive input, and approved the final version of the article for publication.

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