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EFFECTS OF FIELD COLLECTION AND TEMPORARY PRESERVATION METHODS ON THE QUALITY OF ENTOMOLOGICAL SPECIMENS

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Abstract

This study synthesizes real, published quantitative evidence on how field collection and temporary preservation methods influence the taxonomic coverage, abundance structure, morphological integrity, and downstream analytical value of entomological specimens. Numerical results were extracted from peer-reviewed studies comparing sweep nets, hand collection, light-based traps, Malaise traps, yellow pan traps, sticky traps, and preservation regimes. In Lamto, Côte d’Ivoire, 379 insects from nine orders were collected; sweep netting produced the highest capture proportion (0.720) and Shannon diversity ($H' = 1.940$), compared with hand collection (0.232; $H' = 1.375$) and light trapping (0.047; $H' = 0.672$), with a significant diversity difference among methods ($F = 324.458$, $p = 0.0001$). In a Malaysian rice agroecosystem, 86,742 insects were collected: bucket-light traps accounted for 85,666 individuals (98.76% of the total), sticky traps for 795 (0.92%), and sweep nets for 281 (0.32%). Despite its very high catch, the bucket-light trap had low evenness (0.053) and Shannon diversity (0.182), whereas sticky traps had the highest Shannon index (2.248) and evenness (0.778). A study of parasitic Hymenoptera in Indonesian tidal rice fields captured 5,732 individuals representing 320 morphospecies; Malaise traps recovered 62% of morphospecies and 81% of individuals, compared with 28% and 15% for yellow pan traps and 10% and 4% for sweep nets. Metabarcoding of 74 Chinese bulk samples further showed a strong collection-method effect on

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community composition (ANOSIM R = 0.524802, p = 0.001), while the habitat effect was not significant (R = 0.051102, p = 0.078). Preservation experiments across seven insect species showed that high ethanol concentrations (generally ≥90%) increased brittleness in susceptible taxa, whereas long-term DNA preservation generally improved at higher concentrations, demonstrating a morphology–molecular trade-off. These data support a field-to-laboratory quality framework in which collection selectivity, specimen handling, transport, preservation, and metadata completeness are evaluated jointly. A conceptual Specimen Quality Index (SQI) is proposed for future local validation.

Keywords: Entomological specimens, sweep net, hand collecting, light trap, Malaise trap, sticky trap, specimen preservation, morphological integrity, DNA preservation, specimen quality.

1. Introduction

Entomological specimens are fundamental to biodiversity inventories, pest and beneficial-insect monitoring, systematics, morphology, ecology, and molecular studies. Their scientific value, however, depends on more than successful capture. Collection selectivity, mechanical damage, temporary storage, transport, preservation, and metadata quality can all alter what is ultimately available for identification and analysis [1–6].

Method standardization is therefore central to reliable insect monitoring. Montgomery et al. [1] emphasized the need to document sampling effort, habitat, weather, timing, trap configuration, and geographic location. Brown and Matthews [4] similarly showed, through a review of pitfall-trap studies, that large differences in trap design and reporting can undermine comparability. Collection methods are thus experimental filters rather than neutral devices: they determine which taxa and functional groups enter the dataset.

Preservation introduces a second source of methodological bias. Marquina et al. [6] demonstrated that preservation conditions can improve DNA stability while simultaneously increasing specimen brittleness in some taxa, creating a direct

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trade-off between morphological and molecular value. Curation guidance from major collections likewise stresses that preservation strategy must be matched to taxon and downstream purpose and that locality, date, collector, method, and related metadata must remain linked to the physical specimen [9,10].

The aim of this article is to quantify, using real published results, how major field collection and temporary preservation approaches affect entomological sample quality and representativeness. The study also develops a standardized framework for future local validation, including a proposed Specimen Quality Index (SQI).

2. Materials and Methods

For the methodological synthesis, a targeted quantitative evidence review was conducted using peer-reviewed studies and authoritative collection guidance available online up to 4 October 2026. Studies were selected when they reported explicit numerical comparisons of at least two insect collection methods, or experimentally evaluated preservation/transport effects relevant to specimen quality. Values were extracted directly from publisher pages or full-text articles; unreported metrics were not estimated. The only derived values in this article are simple percentages calculated from authors' published counts, and these are explicitly identified as calculated values.

Six core evidence sources were used for quantitative synthesis: Diabaté and Tano [3] for sweep-net, hand, and light-trap performance; Li et al. [2] for metabarcoding-based method effects; Rahim and Ab Hamid [8] for bucket-light, sticky-trap, and sweep-net comparisons in paddy fields; Ikhsan et al. [12] for parasitic Hymenoptera sampling efficiency; Marquina et al. [6] for preservation and transport experiments; and Buchner et al. [7] for standardized large-scale Malaise-trap metabarcoding. Because study objectives, sampling effort, taxa, and habitats differ, the data were not pooled into a single meta-analytic effect size. Instead, published effect statistics and within-study contrasts were compared descriptively.

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To maintain a consistent analytical framework, the evidence was organized into four quality domains: (i) capture efficiency and taxonomic coverage; (ii) assemblage diversity and evenness; (iii) morphological integrity during preservation and transport; and (iv) analytical and metadata suitability. This structure prevents the common error of treating "more individuals captured" as synonymous with "better specimen quality."



Figure 1. Field-to-laboratory quality chain for entomological specimens. Source: author's synthesis based on published monitoring and curation principles [1, 9, 10].

In addition, for future local validation, a conceptual SQI is proposed. Five components are scored from 0 to 5: body integrity (M), wing condition (W), legs and antennae (A), colour/surface preservation (C), and diagnostic usability (D).

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The normalized index is calculated as SQI = ((M + W + A + C + D) / 25) × 100. Because the index has not yet been calibrated against local expert identification outcomes, the thresholds shown below are provisional working categories rather than validated biological cut-points.

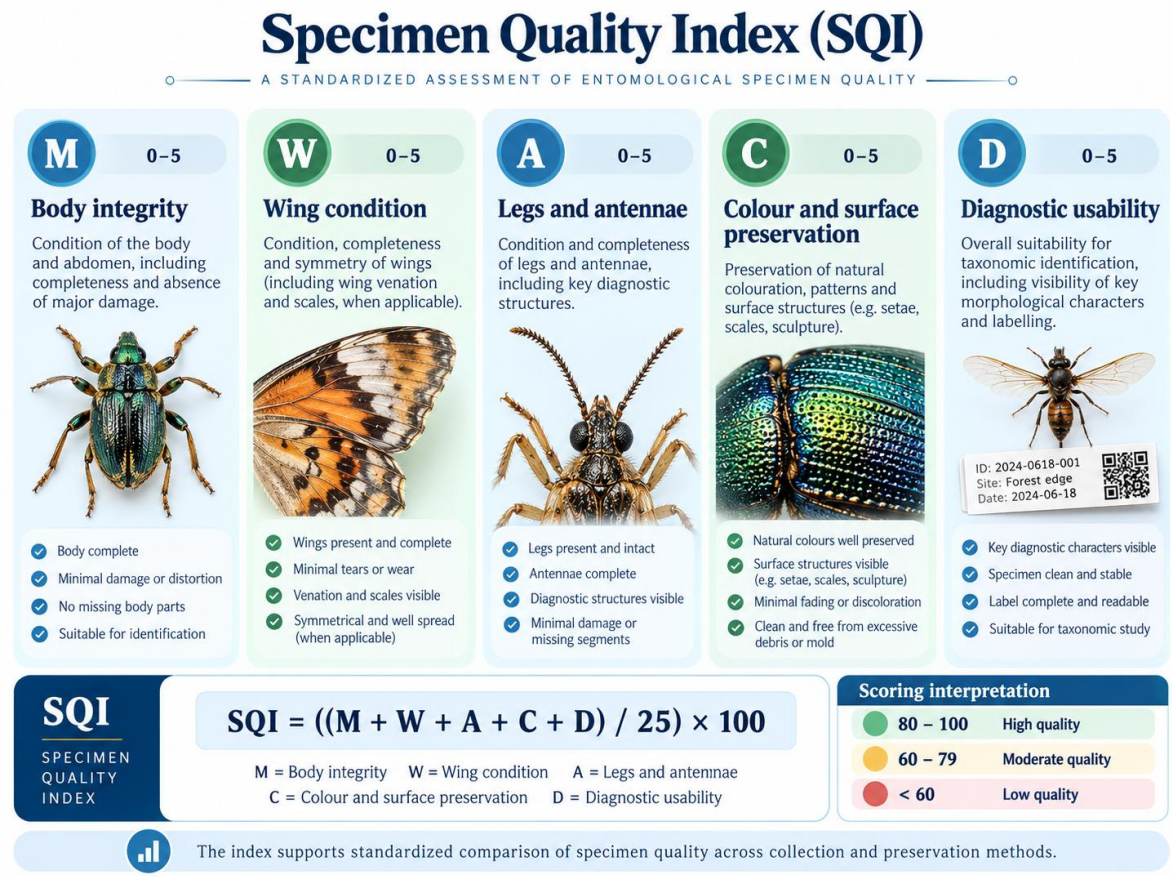


Figure 2. Proposed Specimen Quality Index (SQI).
Source: author's conceptual model for future empirical validation.

3. Results

The quantitative results first show that Diabaté and Tano [3] collected 379 individuals belonging to nine insect orders in Lamto, Côte d'Ivoire. The published capture proportions were 0.720 for sweep netting, 0.232 for hand collecting, and 0.047 for light trapping. Shannon diversity followed the same rank order: H′ = 1.940 for sweep netting, 1.375 for hand collecting, and 0.672 for light

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trapping. The authors reported a significant difference among diversity values ($F = 324.458$, $p = 0.0001$). They also reported method-specific selectivity: hand sampling showed differences among captured orders ($F = 11.340$, $p = 0.006$), while light traps were particularly suitable for Lepidoptera, Coleoptera, and Homoptera ($F = 6.659$, $p = 0.0001$). Thus, the "best" method depended on whether the objective was broad capture, diversity representation, or a specific ecological group.

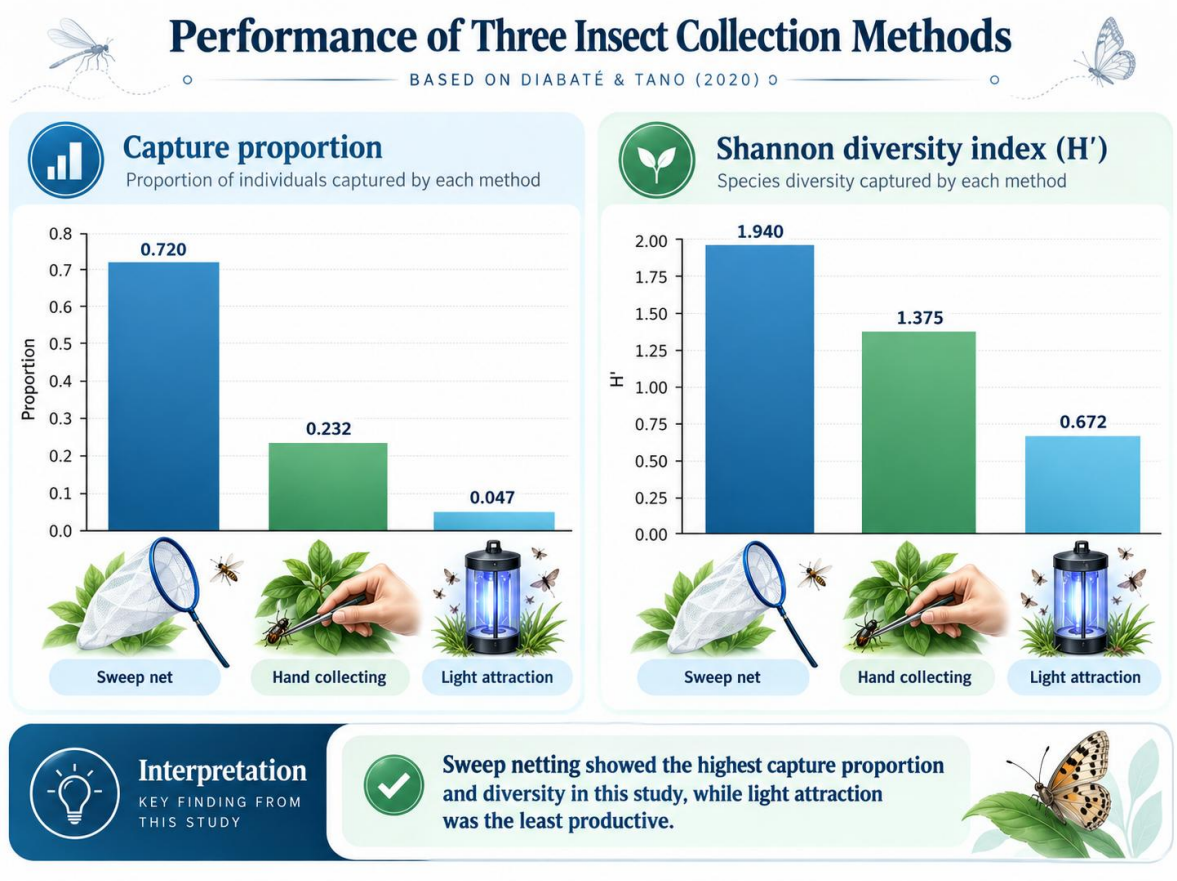


Figure 3. Published capture proportion and Shannon diversity for three collection methods.

Source: visualized from Diabaté and Tano [3].

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A contrasting pattern was reported by Rahim and Ab Hamid [8], who recorded 86,742 insects from 10 orders and 36 families during the reproductive stage of rice in Penang, Malaysia. Bucket-light traps captured 85,666 individuals, sticky traps 795, and sweep nets 281. Calculated from the published counts, these correspond to 98.76%, 0.92%, and 0.32% of all individuals, respectively. Taxonomic coverage was also highest in bucket-light traps (10 orders, 31 families), followed by sticky traps (7 orders, 18 families) and sweep nets (6 orders, 15 families).

However, abundance and taxonomic breadth did not translate into the highest diversity. Sticky traps had the highest Shannon-Wiener index (2.248) and evenness (0.778), whereas the bucket-light trap had the lowest Shannon index (0.182) and evenness (0.053), despite having the highest Margalef richness value (2.64). The authors attributed this contrast to overwhelming dominance by Micronectidae, with 83,225 individuals in the bucket-light sample. This result demonstrates why abundance, richness, and evenness must be interpreted jointly.

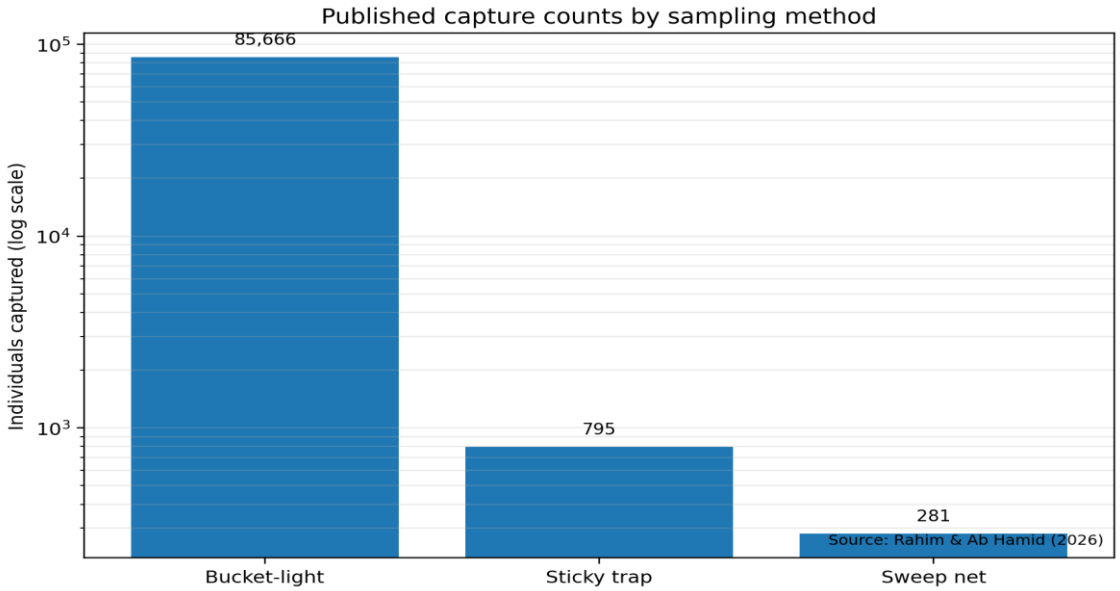


Figure 4. Published insect capture counts in a Malaysian rice agroecosystem (log scale).

Source: Rahim and Ab Hamid [8]. Percentages in the text were calculated from the published counts.

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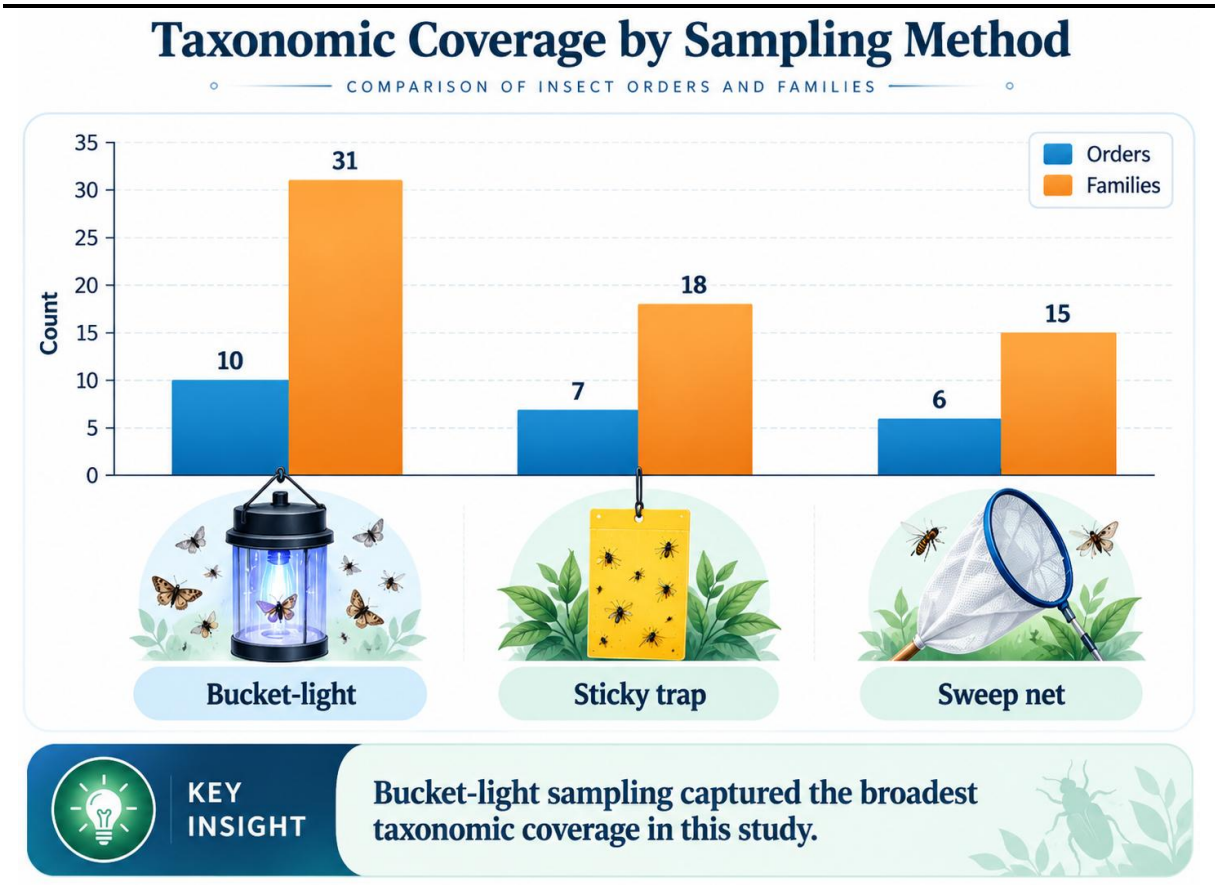


Figure 5. Published taxonomic coverage by sampling method. Source: visualized from Rahim and Ab Hamid [8].

For parasitic Hymenoptera, Ikhsan et al. [12] sampled tidal swamp rice fields in Indragiri Hilir, Indonesia. Across sweep nets, yellow pan traps, and Malaise traps, they collected 5,732 individuals representing 10 superfamilies, 30 families, and 320 morphospecies. Malaise traps accounted for 62% of morphospecies and 81% of individual abundance; yellow pan traps captured 28% of morphospecies and 15% of individuals; sweep nets accounted for 10% of morphospecies and 4% of individuals. The strong divergence between methods reinforces the conclusion that sampling devices are taxon-selective and that a method effective for one target group cannot be generalized to all insects.

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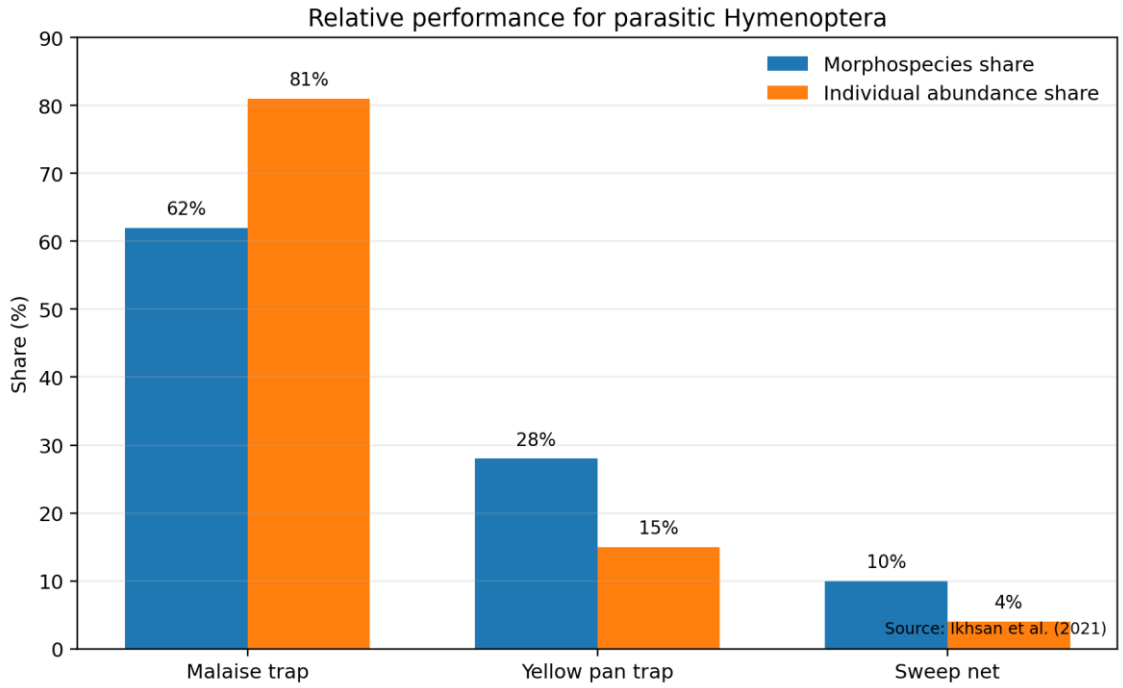


Figure 6. Relative sampling performance for parasitic Hymenoptera in tidal rice fields.

Source: Ikhsan et al. [12].

Metabarcoding evidence further supports method-specific sampling effects. Li et al. [2] analysed 74 bulk samples collected from five habitat types in the Yanshan Mountains using sweep nets, Malaise traps, and light traps. DNA metabarcoding produced 7,427 OTUs at ≥97% sequence similarity, of which 7,083 were assigned to Insecta. Community composition differed strongly among collection methods (ANOSIM $R = 0.524802$, $p = 0.001$), while differences among habitat types were not statistically significant in the same analysis ($R = 0.051102$, $p = 0.078$). These results quantitatively demonstrate that sampling method can have a larger effect on the observed community profile than habitat classification itself within a given survey design.

Preservation effects were quantified experimentally by Marquina et al. [6], who tested seven insect species from four orders across eight ethanol concentrations (30, 50, 70, 80, 90, 95, 97, and 99%) and multiple handling regimes. They found a general increase in brittleness at high concentrations, especially at ≥90%,

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although responses varied substantially among taxa and were strongest in weakly sclerotized species. Intermediate concentrations around 70–80% generally provided better morphological preservation, whereas long-term DNA preservation improved at higher concentrations. For most species, storage at 80% ethanol or lower yielded significantly fewer amplifiable COI copies than 95% after extended room-temperature storage; in four of seven species, significant DNA deterioration appeared from 70–80% downward, while the threshold varied among taxa.

The transport experiment compared 70% and 95% preservation across three handling regimes. For Macrolophus and Aphidoletes, careful carrying produced less damage than rougher handling or postal shipment. Under the more disruptive treatments, both species sustained significantly less damage in 70% than in 95% ethanol. Drosophila showed no significant differences among transport treatments or concentrations. The study also found no significant brittleness effect from repeated freeze–thaw cycles in the taxa that could be analysed. These published results demonstrate a clear morphology–molecular trade-off and show that handling quality can be as important as transport distance. Chemical preservatives should only be handled under institutional safety procedures and qualified supervision.

Table 1. Quantitative results extracted from published studies

Evidence source	Real published quantitative result	Interpretation for specimen quality
Diabaté & Tano [3]	379 individuals; 9 orders. Capture proportion: sweep 0.720, hand 0.232, light 0.047. H′: 1.940, 1.375, 0.672. F = 324.458; p = 0.0001.	Sweep net maximized overall capture/diversity in this survey, while light traps remained selective for nocturnal groups.
Rahim & Ab Hamid [8]	86,742 individuals: bucket-light 85,666; sticky 795; sweep 281. Sticky H′ = 2.248; evenness = 0.778. Bucket-light H′ = 0.182; evenness = 0.053; Margalef = 2.64.	Very high abundance can coexist with low evenness; multiple metrics are needed.

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Ikhsan et al. [12]	5,732 parasitoid Hymenoptera; 320 morphospecies. Malaise: 62% morphospecies / 81% individuals; yellow pan: 28% / 15%; sweep: 10% / 4%.	Target-group efficiency varies sharply among sampling methods.
Li et al. [2]	74 bulk samples; 7,427 OTUs; 7,083 insect OTUs. Method effect R = 0.524802, p = 0.001; habitat R = 0.051102, p = 0.078.	Observed community composition is strongly method-dependent.
Marquina et al. [6]	7 species, 4 orders, 8 ethanol concentrations. High concentration generally increased brittleness; higher concentration improved long-term DNA preservation.	Preservation choice involves a morphology–molecular trade-off and is taxon dependent.
Buchner et al. [7]	1,815 samples from 75 Malaise traps; 10,803 validated insect species; 31,846 total estimated species; average ~1.4 million reads/sample; <€50 per sample.	Standardized collection and laboratory workflows can scale to national biodiversity monitoring.

Note: Results are reproduced as reported by the cited studies; only the Rahim & Ab Hamid capture percentages reported in the text were calculated from published counts.

At a much larger spatial scale, Buchner et al. [7] demonstrated that standardized field collection and laboratory processing can be scaled to national monitoring. Their workflow analysed 1,815 Malaise-trap samples collected from 75 traps across Germany in 2019–2020. Sequencing yielded 52,981 raw OTUs, including 50,087 insect OTUs. A total of 10,803 insect species were validated, and a further 21,043 plausible species were estimated, producing a total estimate of 31,846 species. The reported laboratory workflow cost was below €50 per sample, including supplies, labour, and maintenance. This study is important for the present topic because it shows that collection method, preservation, labeling, and laboratory processing must be designed as one standardized chain if specimen material is to retain high scientific value at scale.

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4. Discussion

Overall, the real published results show that method performance is conditional on target taxon, habitat, and response variable. Sweep netting was superior in Lamto for overall capture proportion and Shannon diversity [3], but in Malaysian paddy fields bucket-light traps dominated total catch and taxonomic breadth while sticky traps produced the highest diversity and evenness [8]. For parasitic Hymenoptera, Malaise traps were far more productive than sweep nets or yellow pan traps [12]. Therefore, the phrase "most effective method" is scientifically incomplete unless it specifies the target group and the metric being optimized.

A particularly clear example of the distinction between capture quantity and specimen quality is provided by the Malaysian results. Bucket-light traps produced 98.76% of all captured individuals but had very low evenness because one family dominated the sample. An abundance-based conclusion alone would therefore overstate ecological representativeness. For curation studies, a further distinction is required between ecological representativeness and physical specimen quality. A method can collect many insects yet yield fragile, damaged, or poorly documented material, while a slower method may retain higher diagnostic value per specimen.

From a preservation perspective, the experiments of Marquina et al. [6] reject the idea that one preservation condition is optimal for all purposes. Morphological quality and DNA preservation can respond in opposite directions, and species differ in sensitivity. This supports a decision framework based on "taxon × intended analysis" rather than a universal preservation setting. Because preservatives may be hazardous, field and laboratory handling should follow institutional SOPs and qualified supervision rather than informal practice.

Finally, physical preservation alone does not guarantee scientific value. A specimen without reliable locality, date, habitat, collection method, effort, and identifier is substantially less useful for reproducible science. International monitoring and museum practice therefore treat metadata as part of the specimen itself [1,10]. For local application, morphological SQI should be supplemented by metadata completeness (%) and identification success (%).

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Table 2. Recommended statistical analysis for a local validation study

Research question	Outcome	Recommended analysis	Report
Do methods differ in SQI?	SQI (0–100)	Kruskal–Wallis; Dunn–Holm post-hoc	H, p, effect size, median [IQR]
Do methods differ in diagnostic usability?	Usable / not usable	χ^2 or Fisher exact; logistic model	OR, 95% CI, p
Does damage type depend on method?	Wing/leg/antenna/body category	Contingency analysis	χ^2, Cramér's V
Are site/date effects important?	SQI or usability	Mixed-effects model	β, 95% CI, random-effect variance
How does capture efficiency differ?	Individuals per unit effort	GLM / negative binomial where appropriate	IRR, 95% CI
Are SQI ratings reproducible?	Component scores	Weighted kappa or ICC	κ/ICC and CI

5. Conclusion

Real published evidence demonstrates that insect collection and preservation methods materially affect the number, composition, diversity, physical integrity, and analytical usefulness of entomological specimens. Sweep nets, light-based methods, sticky traps, Malaise traps, and hand collection each impose characteristic sampling filters. In published examples, the method yielding the highest abundance was not always the method yielding the highest diversity or evenness, and the method best for one target taxon was not necessarily effective for another.

Preservation results show a second trade-off: conditions that improve long-term DNA stability can reduce morphological robustness in susceptible taxa. Accordingly, specimen quality should be treated as the combined outcome of sampling method, handling, transport, preservation, and metadata integrity. The proposed SQI can support future local validation, but its thresholds should be

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calibrated against expert identification success and inter-rater reliability before being used as a formal decision rule.

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