INSTAR: reporting items for invertebrate welfare in research

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Abstract

1. Research-animal welfare concerns have expanded rapidly across taxa over the past decade, with an increasing focus on invertebrates. Recent evidence for affective experience across cephalopod, decapod, and insect taxa, combined with shifts in public attitudes and regulation, has raised the stakes of how invertebrates are used and reported in published research, yet no existing reporting standard adequately addresses invertebrates.

2. Here we propose INSTAR (INvertebrate Standards for Treatment And Reporting) v1.0, an 18-item reporting standard. It does not assess or score welfare; it asks authors to report all facets of the handling and treatment of invertebrates in research and the reasoning behind it, spanning three cross-cutting foundations (Subjects, Procedures, and Ethics & Compliance) and five welfare domains adapted from the Mellor assessment model (Nutrition, Environment, Health, Behaviour, Affective state). The framework is designed for flexible use in both laboratory and field contexts, and is supported by an R package and accompanying web tool that produce a standardised summary figure and report in the spirit of reporting frameworks from other fields.

3. We surveyed 150 recent papers across 15 journals spanning ecology, evolution, behaviour, physiology, and applied invertebrate research, and found that current reporting norms fall substantially short of these standards. The median paper reports just over three in five applicable items, with welfare-specific items (humane endpoints, three-Rs statements, and affective-state indicators) rarely reported.

4. INSTAR is designed to be minimally burdensome. Its primary output is a completed reporting sheet deposited alongside the paper, no more work than the methods paragraph itself, with an optional summary figure rendered from it. Free software fills, renders, and audits reports. We outline practical roles for authors, reviewers, editors, journals, ethics bodies, and funders. Adopting it now would improve the reproducibility and comparability of invertebrate research, strengthen the social licence on which that research depends, and let the field shape the institutional response to invertebrate welfare rather than be shaped by it.

1 | INTRODUCTION

Ethical conduct is core to the scientific enterprise, and there are few domains in which this is rendered more sharply than in the use of animals in research. Standards of practice are seldom static; they shift in response to changing evidence, norms, policy, and knowledge (Drinkwater et al., 2019). Where vivisection without anaesthetic was once routine (Franco, 2013), such procedures are now unjustifiable in all but the most extreme of circumstances, in large part owing to our accumulated knowledge of the capacity for suffering in non-humans. This moral and social progress has been formalised at state and local levels through welfare legislation (Drinkwater et al., 2019), the proliferation of animal ethics bodies governing research practice (Varga et al., 2012), and discipline-spanning frameworks including the ARRIVE guidelines (McGrath et al., 2010; Percie du Sert et al., 2020), the three Rs (Russell & Burch, 1959), and the Five Domains Model (Mellor et al., 2020). Under this last model, welfare is assessed across four physical-functional domains — nutrition, environment, health, and behaviour — whose combined effects register in an integrating fifth (mental or affective state, the capacity for subjective felt experiences with a positive or negative quality). These efforts have been gradual and taxonomically uneven, however, with a near-singular focus on 'higher' vertebrates (i.e. those most related to us) as the subjects of welfare concern (Mather, 2019).

Invertebrates comprise some 99% of described animal biodiversity, yet their welfare interests are rarely examined or weighed alongside those of the vertebrate minority. This is partly a consequence of our nascent understanding of the existence, nature, and distribution of sentience among invertebrates, where sentience refers, at minimum, to the capacity for subjective felt experiences with a positive or negative quality (i.e. valenced experiences), such as pleasure or pain, and whose presence is widely considered a necessary or at least presumptive condition for a

claim of welfare interests (Birch, 2017; Sneddon et al., 2014). The shortfall in attention is not solely a data problem, however. Recent empirical advances have considerably strengthened the case for affective experience in groups long excluded from welfare consideration, from cephalopods (Crook, 2021) and decapod crustaceans (Elwood, 2019) to a growing range of insect taxa including honeybees, crickets, bumblebees, and fruit flies (Gibbons et al., 2022; Manzi et al., 2026; Mikhalevich & Powell, 2020). The evidence is uneven, and stronger in some taxa than others, but it is accumulating. These findings have been accompanied by changes in legal protection for select groups, such as the inclusion of cephalopods and decapod crustaceans under animal welfare legislation in several jurisdictions (Birch et al., 2021). Yet the vast majority of invertebrates remain excluded from legal definitions of 'animals' in both research and welfare law more broadly, and the gap between accumulating evidence and institutional response is widening.

Against this backdrop, one simple and essential advance is to formalise the reporting of the use and treatment of invertebrates in research. There are four compelling reasons to do so. The first is ethics, with a concern for welfare. Evidence continues to accumulate for an experiential capacity across diverse invertebrate taxa (Birch et al., 2021; Gibbons et al., 2022), warranting consideration of their welfare interests in line with other animals (Mather, 2019). In many cases direct evidence is still lacking, albeit largely due to an absence of research effort (Elwood, 2019; Crook, 2021; Gibbons et al., 2022). Nonetheless, prudence under uncertainty, in the form of the precautionary principle as applied to sentience (Birch, 2017; Fischer et al., 2025), counsels reporting and minimisation of potentially harmful treatment.

The second is public legitimacy. The social licence under which animal research operates ultimately depends on public acceptance, and public attitudes toward invertebrate welfare have shifted markedly in recent decades (Drinkwater et al., 2019). Survey work consistently documents

rising concern for the treatment of invertebrates in research, food production, and pest control, with the steepest shifts for cephalopods, decapod crustaceans, and pollinators (Crump et al. 2022; Phillips & McCulloch 2005). The same trend is visible in popular coverage of insect cognition and pain, in the rising prominence of invertebrates in animal-advocacy work, and in increasingly common reader-driven challenges to authors of invertebrate research (Chittka, 2022; Klein & Barron, 2016). Transparent reporting is a precondition for the public discourse and acceptance on which scientific legitimacy depends. Public attitudes do not necessarily track the empirical evidence on sentience and welfare, however, and instead tend to shift in parallel with broader social currents (Clark et al., 2016; Hobson-West & Davies, 2018; Ormandy & Schuppli, 2014). Scientific research both informs and responds to broader conversations, and greater transparency in reporting strengthens both relations.

The third is scientific reproducibility and transparency. Best-practice research is reproducible (Munafò et al., 2017), and reproducibility extends to all aspects of the treatment and handling of study organisms. This is an epistemic matter as much as an ethical one. The known effects of captivity (Mason, 2010), developmental impacts of rearing environments (Burton & Metcalfe, 2014; Norouzitallab et al., 2014), and the generally poor translation of findings between the laboratory and the field (Calisi & Bentley, 2009), and from model systems to clinical application (Varga et al., 2012), often trace, in part, to features of animal handling that are routinely underreported. The same details that bear on welfare also bear on the validity of the scientific measurements. Stressed, injured, or poorly housed animals often do not behave or respond physiologically as they otherwise would (Poole, 1997; Würbel, 2017). Most major journals with vertebrate coverage now require the reporting of welfare-relevant methods (Iossa et al., 2026). Comparable requirements for invertebrate work would extend the same standard to the vast

majority of animals used in research. Transparency also preserves the reasoning behind methodological decisions, rather than only their outcomes. This may be particularly valuable where researchers must balance competing scientific, welfare, and conservation considerations (Lynch et al. 2025). Making those decisions and their justifications explicit creates a record that can be interrogated across studies, allowing future work to examine how decisions are made, which trade-offs are considered, and how these change as evidence, methods and ethical expectations develop. In this sense, reporting decisions and their rationale can themselves generate useful data about research practice.

The fourth is regulatory readiness. The coverage of invertebrates in welfare legislation has expanded substantially over the past decade, and given mounting evidence and public opinion, is likely to continue to expand. Cephalopod molluscs were brought within the scope of EU Directive 2010/63/EU on the protection of animals used for scientific purposes from its commencement in 2013. The UK Animal Welfare (Sentience) Act 2022 formally recognised cephalopod molluscs and decapod crustaceans as sentient, prompted by an independent review of the empirical evidence (Birch et al., 2021; UK Government, 2021). Switzerland prohibited the boiling of live lobsters in 2018 on welfare grounds, and comparable proposals are under active consideration in several other jurisdictions. Expert reviews continue to widen the scope of taxa under serious welfare scrutiny (Gibbons et al., 2022; Mikhalevich & Powell, 2020), and the burden of proof is gradually shifting toward researchers who would treat a taxon as having no welfare interests at all. Researchers operating across jurisdictions therefore face a moving compliance target. The regulatory picture beyond Europe is far more uneven, with most jurisdictions offering no invertebrate-specific welfare provisions (Birch et al., 2021), and this global asymmetry itself makes transparent reporting valuable, since a complete methods section travels regardless of jurisdiction. Voluntarily

considering welfare interests across a broader range of taxa also positions the field to influence the form regulation takes. The formal recognition of cephalopod and decapod sentience in the UK has not yet been accompanied by a comparable shift in how those animals are reported in the published literature, and the broader assumption of non-sentience continues to justify thin welfare reporting across most other invertebrate taxa (Mather, 2019; Mikhalevich & Powell, 2020). Extending vertebrate frameworks piecemeal is at best a partial answer: invertebrates are vastly more diverse and speciose than the vertebrate lineages such frameworks were built for, and welfare reporting for them will need to be developed on invertebrate terms rather than imported wholesale from other taxa.

There is recent precedent for welfare evidence reshaping research and industry practice in adjacent taxa. Work by Sneddon and colleagues on the behavioural and physiological evidence for pain in fish (Sneddon et al., 2014; Sneddon, 2019) accumulated alongside changes in laboratory practice and commercial aquaculture in several jurisdictions and is now reflected in formal welfare guidance for fish research. This arc from initially contested evidence, through concerted research programs, to codified welfare guidance took roughly two decades. The invertebrate case is at an earlier stage, but the trajectory is recognisable: welfare science is developing for a handful of species (e.g. some cephalopods, decapod crustaceans, honeybees, and black soldier flies) and sparse for most others, and formal recognition remains limited to select taxa even where evidence is strong. Behavioural and physiological evidence is accumulating, and public attitudes are shifting in much the same way. The time is ripe for the implementation of changes to research practice, to support and inform future regulatory shift.

Here we detail INSTAR (INvertebrate Standards for Treatment And Reporting), a reporting standard for invertebrate treatment and welfare in research, with accompanying tools

designed to make adoption as low-friction as possible. Motivated by the rationale above, it is designed for applications ranging from ecology and evolution through physiology, neurobiology, medicine, and mass rearing for food and feed. INSTAR is designed to be minimally burdensome. Its primary output is a completed reporting sheet, deposited alongside the paper, which is much the same work as writing the methods paragraph. A standardised summary figure renders from that sheet as an option rather than a requirement. Free software fills, renders, and audits reports. We first present an adaptation of the Five Domains Model refined to better accommodate invertebrates and the methodological diversity of field and laboratory work. The model was originally formulated for welfare assessment, and we use it here as a reporting scaffold instead, taking inspiration from the PRISMA (Page et al., 2021) and ROSES (Haddaway et al., 2018) frameworks that standardised reporting for evidence synthesis in clinical and environmental sciences respectively. We propose a standardised visualisation to support this reporting and provide an R package and web interface for its ready generation. We then survey the recent literature to characterise current reporting norms against which the proposed standard might be evaluated.

2 | A FRAMEWORK FOR REPORTING INVERTEBRATE WELFARE

We propose 18 reporting items organised into eight groups (Table 1). Each item carries an applicability code for both laboratory and field studies (see Table 1). For each item, INSTAR asks for both a description of what was done and, wherever relevant, the reasoning behind it. We use ‘welfare’ throughout in the broad sense, encompassing both an animal’s inferred affective state and the physical, environmental, and social conditions that likely shape it. Three of the groups are cross-cutting foundations covering Subjects, Procedures, and Ethics and Compliance. Five are

welfare domains adapted from the Mellor Five Domains Model (Mellor et al., 2020), namely Nutrition, Environment, Health, Behaviour, and Affective state. For concise reporting, we retain the shorter labels Environment and Behaviour in place of the 2020 terms Physical Environment and Behavioural Interactions; the latter's explicit human-animal interaction content — capture, handling, transport, and end-of-study handling — is distributed across our Procedures and End of Study items rather than duplicated within Behaviour. Each item is intended to be covered in a sentence or two of methods prose. We follow Mellor et al. (2020) specifically, both because it is the anchoring statement of the Five Domains Model in its current form (with subsequent refinement in Littlewood et al., 2026), and because its explicit incorporation of human-animal interactions is directly applicable to invertebrate research, where the researcher is typically the principal external influence on the animal's welfare. The Five Domains welfare model we adapt was developed for vertebrates, and taxon-specific welfare-science guidance at the level of individual invertebrate orders, families, and species will ultimately be far preferable. INSTAR treats the model as a reporting scaffold that can absorb better welfare-science inputs as they arrive.

Three design choices warrant brief comment. First, the framework is for reporting, not assessment. It is not a scorecard and it is not intended to evaluate the welfare of animals in a given study. It is intended only to standardise the information that is communicated. Assessment requires defensible, often taxon-specific welfare indicators that the field is still developing (Narshi et al., 2022), whereas reporting requires only that what was done, and why, be recorded. Requiring justification is not intended to prescribe which decisions are acceptable, but to make the reasoning underlying those decisions transparent. Reporting is the necessary first step, and assessment can follow.

Second, the framework treats laboratory and field studies on equal footing and accommodates lethal sampling as a routine case rather than an edge case. Each item is flagged according to whether it should be reported in laboratory work, in field work, or both, with a third applicability state ('conditional') used for items that apply only under particular circumstances. Anaesthesia and analgesia, for instance, are conditional in both settings: the item applies where a procedure is likely to be harmful, and not otherwise. Items that presuppose holding (acclimation, ongoing health monitoring) are marked not applicable for collect-and-kill designs, and the End-of-Study item documents the killing method and voucher (a preserved specimen archived for future reference) deposition. This is a deliberate departure from existing welfare reporting guidance, which has been oriented overwhelmingly toward laboratory and clinical contexts using vertebrates and scales poorly to the field-heavy, methodologically heterogeneous work that characterises research involving invertebrates.

Third, the framework anticipates two broad reporting scales in invertebrate research. Single-species or small-sample studies report at the individual or cohort level. Bulk and broad-sampling work, including pitfall trapping, Malaise trapping, light trapping, mass-rearing of farmed or model species, and work on undescribed taxa reports at the level of sampling effort, colony, or cycle, with individual identification and counting often impractical or impossible. INSTAR accommodates both. Items that presuppose individual-level information (sample size, attrition, injury counts) accept aggregated or effort-based answers (e.g. trap-days deployed, colony-cycles observed) where individual answers are not tractable, with the unit of replication (colony, cohort, trap-day, batch) stated (Rowe et al., 2024).

Finally, a brief note on scope: nothing in the framework is specific to invertebrates, and it can be used as readily for vertebrate work. We name it for invertebrates deliberately. Vertebrate

research is already served by mature reporting standards including ARRIVE (Percie du Sert et al., 2020). ARRIVE is also doing something different, covering randomisation, blinding and sample-size justification: experimental rigour rather than welfare. Where the two overlap, its items assume an animal is a vertebrate held in a laboratory, and so say little about field collection, mass rearing, or animals handled in bulk. Naming this framework for invertebrates guards against motivations a general-purpose checklist would lose.

2.1 | Foundations

Subjects. This includes taxonomic identification to the lowest practicable level (and the method used to determine it), life stage and sex, source (wild-caught, laboratory colony, or commercial supplier), culture history for captive-reared stock, and sample size used, with any attrition between collection and analysis accounted for. Source and culture history are among the most consistently absent items in current reporting on invertebrates (see section 3), and among the most consequential for the interpretation of behavioural and physiological measurements. For bulk-sampling or mass-rearing work, reports can be order-of-magnitude counts or ranges, and the unit of replication (colony, cycle, trap-day, batch), rather than individual totals.

Procedures. This covers all handling including capture and transport from field or supplier, routine handling and restraint, marking and tagging, anaesthesia and immobilisation, analgesia, surgical or invasive procedures, and containment and biosecurity. We separate analgesia from anaesthesia because the two address different welfare objectives and because analgesia is the more under-considered of the pair in invertebrate work, often omitted without comment. For studies performing no invasive procedures, an explicit statement to that effect — rather than silence — is the reporting expectation. We treat biosecurity as a welfare-adjacent item. Escape of

non-native study organisms is an environmental matter (often with welfare implication), but the conditions that prevent escape (containment, disposal protocols) belong with handling. Where individual handling is not practicable (pitfall, Malaise, light, or sticky trapping and similar), report sampling effort (trap-days, trap-nights, deployment volume), trap design and check routine, and any measures taken to reduce by-catch, retention time, and trapped-animal suffering.

Ethics and Compliance. This includes the institutional context of the work, covering formal ethics review (undertaken with permit numbers, or an explicit statement that none was required), collection and import permits, conservation status of focal taxa and any consequent considerations, predefined humane endpoints, anticipated and observed non-target impacts in field work, and a brief statement of how the three Rs informed study design. The framework treats reporting of welfare reasoning (including the ethics-review status or explicit statement that none applied) and a three-Rs statement as required items for all studies, regardless of regulatory mandate (a stance responsive to the pattern of invertebrate research proceeding without formal ethics review; Drinkwater et al., 2019), on the rationale outlined in the introduction.

2.2 | Welfare domains

Nutrition. What animals were fed (or baited with), how often and how much, with what access to water or moisture, and any pre- or post-experimental fasting. Diet composition and source are routinely omitted in invertebrate work despite well-established effects on physiology, behaviour, and condition (Behmer, 2009; Simpson & Raubenheimer, 2012).

Environment. The physical and abiotic surroundings of the animals. This includes housing materials, dimensions, substrate, and structural complexity, along with stocking density and grouping, temperature, humidity, ventilation, photoperiod and lighting, water quality for aquatic species, cleaning frequency and protocol, and any acclimation period before procedures. For field

studies it also covers the habitat conditions and any trapping methods used. Photoperiod and density in particular can impact reproducibility as well as welfare and should be made explicit.

Health. The methods by which the condition of animals was assessed (behavioural and physical indicators including responsiveness, posture, integument, and autotomy), any screening for disease or parasites, the frequency of welfare monitoring, and any unexpected injuries or deaths together with their suspected causes and any interventions taken in response. This domain also covers end-of-study disposition: method of killing (framed as euthanasia, sacrifice, or slaughter as appropriate to context) and justification, release protocols for field-collected animals, post-study care or rehoming, and voucher specimen deposition. For colony or industrial-scale work where individual death counts are not meaningful (because of scale, cannibalism, or routine attrition), report the disease-screening and prevention regime, density and condition monitoring, and any conditions under which cohort losses triggered intervention. For end-of-study reporting in mass-rearing work, the killing method and scale should be described using the terminology the welfare community uses for that context (i.e. slaughter method for farmed insects; see Rowe et al., 2024, for example taxon-specific recommendations). For studies considering release of field-collected or laboratory-maintained animals, briefly state the reasoning behind the choice between release, continued holding, rehoming, and slaughter, including disease-spread risk to wild conspecifics and any maladaptation incurred during captivity.

Behaviour. The opportunities the experimental setup provided (or constrained) for species-typical behaviours, including any choice afforded, the refugia or enrichment provided, and the measures taken to minimise disturbance. The first of these, behavioural constraint, is arguably where much of the welfare cost of invertebrate lab work lies, when animals are housed in

conditions that preclude the behaviours that define their natural lives. For social or gregarious species, report access to conspecifics and the structure of social grouping.

Affective state. The taxon-appropriate behavioural and physiological indicators of stress, pain, or distress that were monitored, and the precautionary measures adopted where capacity for affective experience is uncertain. Affective indicators are the domain where invertebrate welfare science is least settled, and transparent reporting of what was and was not monitored will support the enrichment of the evidence base. We adopt ‘affective state’ in place of the original ‘mental state’ used by Mellor and colleagues (2020) for two reasons. It is somewhat less anthropomorphically loaded, which is a virtue when applied to taxa whose mental lives are uncertain. It also more naturally accommodates the precautionary stance that the current state of much evidence requires. The term also aligns with the vocabulary of choice in the invertebrate welfare literature (Birch, 2017; Gibbons et al., 2022; Sneddon et al., 2014), which treats affective state underlying valenced responses whose existence can be evidenced without asserting the broader phenomenal consciousness that 'mental state' can be read to imply.

2.3 | Completing and sharing an INSTAR report

The full framework (Table 1) is intended to fit within one or two methods paragraphs in any given study. Not every item applies in any one study, and items marked as conditional or not applicable can be omitted. To lower the burden of compliance further, the reporting sheet provided in supplementary material (S2) carries one row per item with a free-text column for what the study reports, so completing it is the same work as writing the methods paragraph. Depositing that completed sheet alongside the paper is the primary act of compliance under INSTAR, and makes the reporting machine-readable as well as human-readable. To support comparison across studies, the sheet also renders as a standardised summary figure that records the substantive content

reported against each item. Figure 1 shows the figure applied to a recent paper of ours (Manzi et al., 2026) as a worked exemplar. The figure is generated by an R package (*instarreport*) or an accompanying web interface (https://instar-statement.org), both of which take the set of INSTAR items addressed by a study and produce a publication-ready graphic suitable for inclusion as supplementary material (e.g. Fig. 1; see supplement S1 for full installation and usage guidance). The intended analogues are the PRISMA flow diagram for systematic reviews in medicine (Page et al., 2021) and the ROSES forms and flow diagram for environmental evidence synthesis (Haddaway et al., 2018). Each was designed to lower the cognitive cost of comparing methods reporting across studies and support authors and reviewers in pursuing more complete reporting by making gaps visible at a glance. Journal endorsement of PRISMA, for example, is associated with measurably more complete and methodologically stronger systematic reviews (Panic et al., 2013), though the size of that gain depends on whether journals enforce a standard or merely endorse it (Leung et al., 2018).

The 18 items are a floor rather than a ceiling, and authors should report additional welfare-relevant information wherever it applies. The framework is intended as a living document, and this represents its initial release as version 1.0. Items, descriptions, and applicability flags will be revised as community feedback accumulates and as the evidence base on invertebrate sentience and welfare continues to evolve. We warmly invite ongoing community engagement.

2.4 | Software

Two implementations accompany the framework, both freely available online from https://instar-statement.org. The R package *instarreport* provides the item set as data, three routes to completing it (the reporting sheet, an interactive console prompt, or direct assignment in a script), validation against the canonical items, and functions that write both deposit artefacts: the

completed sheet and the summary figure. Because a deposited sheet is structured text rather than a picture, the package also reads sheets back in: a directory of them can be loaded and summarised in two calls, giving both the content of what was reported and coverage per item across a body of studies rather than one study at a time. That opens the door to meta-research on welfare reporting: tracking norms over time, comparing them across journals and subdisciplines, and testing whether interventions such as INSTAR shift practice. For those who do not work in R, an accompanying web application offers the same functionality in a browser, previewing the figure as items are filled in and accepting an uploaded sheet as an alternative to typing. It runs entirely within the browser, so nothing entered is transmitted to a server and unpublished methods detail need not leave the user's own machine. Both are released under an MIT licence and openly developed at https://github.com/thomased/instarreport, and supplement S1 gives installation and usage guidance for each, as do the supporting vignettes and instructions available at the framework's home page.

3 | THE CURRENT STATE OF REPORTING

To characterise current reporting norms against which INSTAR might be evaluated, we surveyed the recent invertebrate research literature across the diverse disciplines covered by INSTAR for its coverage of the reporting items proposed above. We screened 150 papers (10 selected per journal from recent 2026 issues) using invertebrate study organisms across 15 journals spanning ecology and evolution, behaviour, physiology and neurobiology, invertebrate pathology, mass rearing for food and feed, and general biology (*Animal Behaviour, Aquaculture, Behavioral Ecology, Ecology Letters, Ethology, Functional Ecology, Journal of Comparative Physiology A, Journal of Experimental Biology, Journal of Insects as Food and Feed, Journal of Invertebrate*

Pathology, PLOS Biology, PLOS ONE, Proceedings of the Royal Society B, Royal Society Open Science, Scientific Reports). Papers were included where invertebrates were the focal study organism and the work involved live animals. Our selection of papers was haphazard rather than a formal sampling design. For each journal we browsed recent 2026 issues in publication order and took the first ten empirical studies of live invertebrates, without keyword pre-filtering or exclusion by topic beyond that. The intent here is a heuristic characterisation of current reporting norms, not a systematic review, and the sample should be interpreted accordingly. For each included paper we obtained the methods section from the full-text PDF and scored it against the 18 INSTAR items using Claude Haiku 4.5 (Anthropic), presented with a compact rubric describing each item and instructed to return, per item, one of reported (Y), not reported (N), not applicable to the study design (NA). To validate the automated scoring, 10% of papers (one per journal) were re-scored by hand against the same rubric and used to refine the scoring prompts. Because that sample informed the refinement, we then drew a second, held-out sample of the same size, one paper per journal selected at random from those not used in refinement, and re-scored it by hand. Agreement was 97% (262 of 270 item-level scores). Every disagreement was a case of the automated scoring crediting a study with an item it had not clearly reported, so the coverage figures below are, if anything, slight overestimates. Disagreements clustered on the least literal items, chiefly affective-state indicators, injury and mortality, and biosecurity. The automated scores were retained as given rather than hand-corrected, so that the validated subset is treated no differently from the rest. Items not applicable to a paper were excluded from that paper's denominator. We computed per-item and per-paper coverage, and rendered Figure 2, using the *instarreport* package, which derives both directly from the scoring table.

Across the 150 papers scored, median per-paper coverage of applicable items was 62.5% (mean 60.7%), with reporting extremely uneven across items and journals (Figure 2). Subjects and Procedures foundations were near-universally reported — taxonomic identification at 99% of applicable papers and capture, transport, and handling at 97%, source and sample size at 96% each — as were housing conditions (88%) and diet (84%) for captive studies. Welfare-explicit items were dramatically weaker: humane endpoints appeared in only 10% of papers, welfare and three-Rs statements in 17%, and affective-state indicators in 32%. Coverage varied substantially across journals, with median per-paper coverage ranging from 42.5% (Journal of Insects as Food and Feed) to 78% (Animal Behaviour). This pattern reflects the current reporting norms INSTAR is designed to shift.

4 | DISCUSSION

The case for taking invertebrate welfare seriously is becoming increasingly compelling, but the reporting that should accompany this has not kept pace. INSTAR is a first attempt at encouraging and standardising comprehensive reporting in research using invertebrates. It is adapted from existing welfare-reporting conventions, amended for field and methodologically diverse work, and pitched at a level that any reasonable study should be able to meet with a paragraph of methods prose. The intent is not to constrain or direct research but to formalise what most welfare-conscious researchers are already doing implicitly, and to encourage those who are not. Nor is it a welfare guarantee, in that a complete report describes only what was done, it does not itself certify that the treatment was appropriate.

The benefits of a shared reporting framework accumulate well beyond welfare considerations. Standardised reporting makes methods comparable across studies, and exposes

incidental design features (e.g. photoperiod, density, handling regime) that themselves are central to research reproducibility. It lowers the editorial cost of asking 'how were the animals treated' and gives reviewers a defensible basis for raising welfare-adjacent points where relevant. Standardised reports also constitute a growing corpus that future syntheses can draw on, from meta-analyses of welfare-relevant methods choices to comparative work on invertebrate research practice. Because the reporting sheet is ideally deposited as structured plain text rather than only as a figure, those syntheses can be assembled by reading the deposited files directly without re-extracting the information from prose, and the R package supports this directly. More broadly, INSTAR reporting responds to the common framing that 'no ethics permission was required'. That phrase reflects the reality that most institutional ethics processes still do not cover invertebrate work, rather than any ethical reasoning. Where institutional review does not apply, INSTAR asks the author to state their own such reasoning directly (as best they can given prevailing uncertainties in the evidence base), rather than left implicit in an appeal to regulatory status.

Further benefits may be particularly clear for field ecology and conservation, where welfare considerations often form part of a broader set of value trade-offs (Lynch et al. 2025). Biodiversity surveys, ecological monitoring, and conservation research may require lethal or otherwise intrusive sampling, sometimes at considerable scale, because the information generated is intended to support conservation. In such cases, transparency requires more than documenting what was done: it also requires making visible why a particular approach and sampling intensity were chosen, what alternatives were considered, and how potential impacts on focal and non-target organisms were weighed against the scientific or conservation objectives. INSTAR does not seek to adjudicate these decisions but instead provides a means of recording their rationale. Accumulated across studies, such information may itself become useful evidence for

436 understanding how researchers navigate competing welfare, scientific and conservation
437 considerations, and how those decisions change through time.

438 Citizen science provides a further reason for making this reasoning visible. Where
439 members of the public participate directly in collecting or handling invertebrates, the audience for
440 transparent reporting extends beyond authors, reviewers, and regulators to the participants
441 themselves. Projects involving lethal sampling in particular may generate legitimate questions
442 about necessity, proportionality, bycatch and conservation benefit, which are rarely made explicit
443 (Lynch et al., 2025). A clear account of both what was done and why provides a basis for
444 communicating these decisions consistently to volunteers, funders, journalists and the wider
445 public. Reporting frameworks such as INSTAR may therefore have value not only as components
446 of the scientific record, but also as tools for public engagement and for maintaining the trust on
447 which participatory research depends.

448 Adoption is the obvious next step and depends on action by several constituencies.
449 Individual researchers are the primary stakeholders the framework is written for, and they can
450 adopt it without permission or coordination, while journals, editors, reviewers, and ethics
451 committees can accelerate the shift. Authors can include the framework's items in their methods
452 text without any change to their experimental practice. The marginal cost is a paragraph. The
453 marginal benefit, even setting welfare aside, is a methods section more closely aligned with the
454 requirements of basic reproducibility. Reviewers can ask for items that are missing, in the same
455 way that the absence of sample sizes or statistical reporting is routinely flagged. Editors and
456 journals can incorporate the framework into instructions for authors, either as a recommended
457 supplementary checklist (the PRISMA and ROSES model) or as a required methods element for
458 studies using invertebrate organisms. Several of the journals surveyed in the present work already

require some welfare reporting for vertebrate studies, and the asymmetry between vertebrate and invertebrate requirements increasingly warrants reconsideration (Iossa et al., 2026). Ethics bodies can align review procedures with the framework's domains, both for studies subject to formal review and as guidance for those that are not. There is, finally, scope for funders to require welfare reporting as a condition of award, an approach that has accelerated adoption of other reporting standards. Several venues have begun to ask for more transparent welfare reporting in invertebrate studies (e.g. Iossa et al., 2026), and INSTAR is intended to give authors and editors structured guidance, and a shared template, against which to do so. Learned societies including the Royal Entomological Society have also published statements on the ethical treatment of insects (Royal Entomological Society, 2024).

A few aspects of INSTAR's scope and trajectory bear noting. The framework is voluntary, and voluntary frameworks have a mixed history. Meeting the full set of items takes researcher time, particularly for high-throughput or field-collected work, and that effort will not always feel proportionate to any single study. But transparency compounds, with each additional complete methods section making the collective evidence base more reproducible and more useful. PRISMA, ROSES, the ARRIVE guidelines, and similar reporting standards have raised baseline reporting in their respective fields, but adoption has been gradual and uneven (Hair et al., 2019; Leung et al., 2018). We expect a similar trajectory here and would welcome a faster one. Enforcement is a further practical hurdle since even for vertebrate research adherence to standards such as ARRIVE has proved uneven, and we take an aspirational view. The point is to shift expectations and give readers, reviewers, and editors a defensible basis for asking for essential details. The framework is also adapted from existing instruments rather than derived from first principles. We do not claim that the Five Domains Model, even with the modifications proposed,

is the optimal organising structure for thinking about invertebrate welfare. We claim only that it is sufficiently mature to anchor a reporting standard. Future work refining the welfare science of particular taxa will likely warrant revision of the framework's items, and we anticipate releasing updated versions on the same cadence as the underlying evidence base shifts. INSTAR is also a reporting framework, not a research-permissibility framework. It does not address the prior question of whether a given study should be conducted at all. A further substantive practical issue is that data gaps for invertebrates are real and severe (Cardoso et al., 2011). Taxon-specific welfare indicators, euthanasia or slaughter guidance, and even basic natural history are absent for many invertebrate groups, and most species (Stork, 2018). The framework's response, where the answer to an item is genuinely unknown, is to report the gap explicitly, name the precautionary actions adopted, and avoid the alternative of silent omission. For invertebrates this can mean, for example, defaulting to killing methods with the strongest available evidence for reduced nociceptive response (such as rapid chilling followed by physical destruction rather than CO_2 or slow desiccation) even where regulatory guidance is silent. Gap-reporting is itself a contribution to the cumulative evidence base from which taxon-specific guidance will eventually accumulate.

Welfare science for invertebrates is at an inflection point. The evidence base for affective experience is accumulating, public and regulatory attention is turning, and legal protections, though limited, are expanding. The next decade will likely see substantial change in the institutional context within which invertebrate research is conducted. There are several possible responses to this trajectory. One is to wait until regulation forces alignment, accepting the costs of last-minute change and a reduced hand in shaping what that regulation requires. Researchers are usually consulted when such frameworks are developed, but consultation on a settled agenda is weaker than helping set it. Another is to act in advance, formalising reporting now while doing so

remains low-cost, using the resulting transparency to inform community standards, public conversation, and policy, and ensuring that the institutional shape that emerges is one that researchers have meaningfully helped to design. The framework offered here is intended as a contribution to the second response. We invite stakeholders to contribute to its refinement and adoption.

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AUTHOR CONTRIBUTIONS

T.E.W. and E.D. contributed equally to conceptualisation, methodology, writing: original draft, and writing: review & editing. T.E.W. additionally led software development (R package and Shiny web tool), formal analysis, and data curation. K.L. contributed to conceptualisation, methodology, and writing: review & editing. A.G.H., T.L., C.Y.F., J.A., and K.U. contributed to methodology and writing: review & editing.

DATA AVAILABILITY STATEMENT

The reporting items (Table 1) are provided as a blank, ready-to-complete reporting sheet in supplementary material, as plain text (INSTAR.csv) and as an identically structured spreadsheet (INSTAR.xlsx). The R package *instarreport* and the web tool (https://instar-statement.org) are freely available there, along with current installation instructions and the source code. The data underlying section 3, comprising bibliographic records and per-item scores for all 150 surveyed papers together with the scoring notes, and the scripts that reproduce every value reported there and Figure 2, are archived at https://github.com/thomased/ms_instar. All are publicly accessible; no login or request for access is required. Both repositories will be archived with a permanent DOI on acceptance.

CONFLICT OF INTEREST

The authors declare no competing interests.

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Figures and Tables

Figure 1: Standardised INSTAR summary figure for a paper, as producible by the *instarreport* R package or accompanying web tool, shown here for a recent study of pain-like behaviour in house crickets (Manzi et al., 2026) as a worked exemplar. Each cell carries the substantive content the study reported for the corresponding framework item, grouped into three cross-cutting foundations (blue, left) and five welfare domains (green, right); colour distinguishes the two groupings and matches the coding used in Figure 2 and in the descriptions below. Cells marked "Not reported" in muted italic indicate items the paper does not address. Cells marked "Not applicable" in grey indicate items that do not apply to the study design. The figure is intended for inclusion as supplementary material with any paper using invertebrate study organisms.

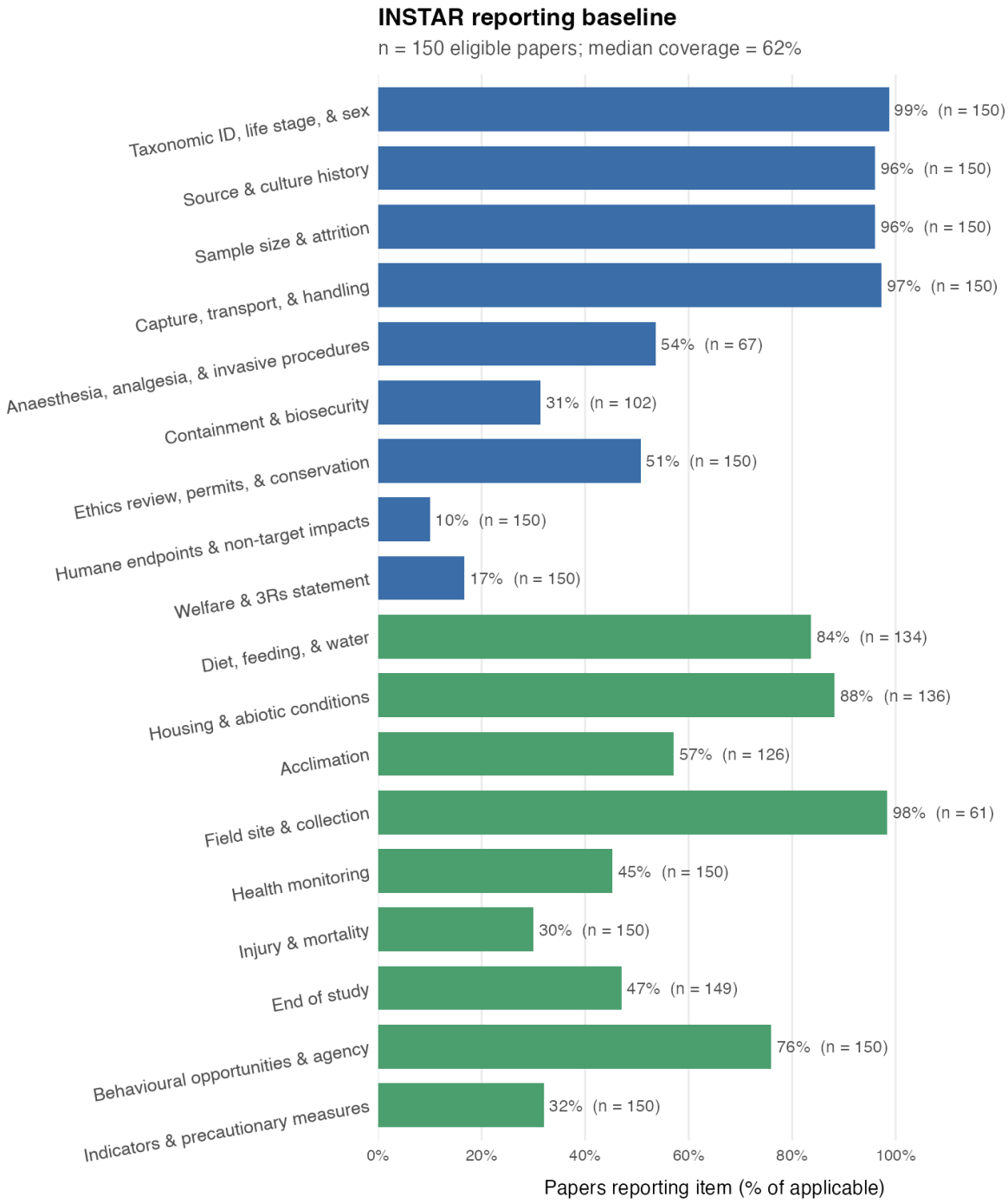

Figure 2: Baseline reporting of the 18 INSTAR items across 150 empirical invertebrate studies published in 2025-2026 in 15 journals (see §3 for methods). Bars show the percentage of papers reporting each item, with the denominator restricted to papers for which the item was applicable (n given in parentheses). The three cross-cutting foundations (Subjects, Procedures, Ethics & Compliance) are shown in blue and the five welfare domains (Nutrition, Environment, Health, Behaviour, Affective state) in green, following Figure 1 and Table 1.

Table 1. The INSTAR framework. Eighteen reporting items grouped into three cross-cutting foundations (Subjects, Procedures, Ethics & Compliance) and five welfare domains adapted from the Mellor Five Domains Model (Nutrition, Environment, Health, Behaviour, Affective state). Applicability is indicated for laboratory and field studies as Y (should be reported), C (report if applicable), or — (not applicable). Full item descriptions are provided with the reporting sheet in supplementary material (S2).

Domain	Item	Description	Lab	Field
Subjects	**Taxonomic ID, life stage, & sex**	Identification to the lowest practicable level (with method); life stage and sex where determinable; voucher specimens or reference imagery deposited where appropriate.	**Y**	**Y**
	Source & culture history	Wild-collected (locality, date), laboratory colony (founding stock, source, date), or commercial supplier (named). For captive stock: generations in captivity, rearing conditions, selection or inbreeding history.	**Y**	**Y**
	Sample size & attrition	Individuals collected vs. analysed, with attrition accounted for. Justification of sample size (a priori power, pilot data, or stated convention). Bulk or mass-rearing work: report order-of-magnitude counts or ranges and the unit of replication (colony, cycle, trap-day, batch).	**Y**	**Y**
Procedures	**Capture, transport, & handling**	Capture method (including lethal sampling); transport duration, conditions, mortality. Handling and restraint. Marking or tagging method, tag mass where relevant, retention checks. Taxonomically broad sampling (pitfall, Malaise, light, sticky): report sampling effort (trap-days, trap-nights), trap design and check routine, and by-catch / retention-time mitigation.	**Y**	**Y**
	Anaesthesia, analgesia, & invasive procedures	Anaesthetic agent or method (agent and dose); induction and recovery times; justification. Analgesia (agent and dose) or explicit justification for omission. For surgery: procedure, instruments, sterility, duration, recovery.	**C**	**C**
	Containment & biosecurity	Measures to prevent escape (particularly of non-native taxa); disposal of waste and contaminated material.	**Y**	**C**
Ethics & Compliance	**Ethics review, permits, & conservation status**	Institutional or regulatory review and permit numbers, or an explicit statement that none was required. Collection or import permits. IUCN, national, or regional conservation status. Country, state, and any translocation between jurisdictions (including distance from point of collection where relevant).	**Y**	**Y**
	Humane endpoints & non-target impacts	Predefined criteria for early termination on welfare grounds and any instances triggered. For field work: anticipated and observed non-target welfare impacts with mitigation strategies.	**Y**	**Y**
	Welfare & 3Rs statement	Brief statement of welfare considerations and how the three Rs (Replacement, Reduction, Refinement) informed study design.	**Y**	**Y**
Nutrition	**Diet, feeding, & water**	Composition and source of diet or bait; preparation; feeding frequency and access; water or moisture provision; any pre- or post-experimental fasting with justification.	**Y**	**C**
Environment	**Housing & abiotic conditions**	Enclosure materials, dimensions, substrate, structural complexity; stocking density and grouping; temperature, humidity, ventilation, photoperiod and lighting; water parameters for aquatic species; enclosure cleaning frequency and protocol.	**Y**	**C**
	Acclimation	Duration and conditions of any acclimation period before experimental procedures.	**Y**	**C**

	Field site & collection	Habitat type, location, abiotic conditions, seasonality. Trap design, placement, deployment, checking frequency, and measures to limit injury, predation, exposure, or desiccation.	**—**	**Y**
Health	**Health monitoring**	Methods and criteria for assessing physical condition (e.g., responsiveness, posture, integument, autotomy). Disease or parasite screening. Frequency of welfare checks.	**Y**	**C**
	Injury & mortality	Number and timing of injuries and unexpected deaths, suspected causes, and any interventions or protocol adjustments. Industrial / mass-rearing: report disease-screening and prevention regime and density-condition monitoring in lieu of per-individual counts.	**Y**	**Y**
	End of study	Method of killing (euthanasia, sacrifice, or slaughter as contextually appropriate) and justification; release protocols for field-collected animals; continued holding, rehoming, or transfer; voucher specimen deposition. For mass-rearing work, use 'slaughter' as the contextually appropriate term. For release decisions, note the reasoning (disease-spread risk, captivity-induced maladaptation).	**Y**	**Y**
Behaviour	**Behavioural opportunities, enrichment, & disturbance**	Aspects of the setup that supported or constrained species-typical behaviour. Provision of refugia or enrichment. Measures to reduce ambient disturbance. For social or gregarious species, access to conspecifics and the structure of social grouping. Opportunities for agency and choice (e.g., control over aspects of the physical or social environment).	**Y**	**Y**
Affective state	**Indicators & precautionary measures**	Taxon-appropriate behavioural and physiological indicators of stress, pain, or distress monitored, and how interpreted. Where capacity for affective experience is uncertain, the precautionary measures adopted.	**Y**	**Y**

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