"Apart from [a] stronger emphasis in quantitative methods and models, perhaps the most significant development altering the field of forensic anthropology is the introduction of forensic taphonomy methods and principles for data collection and analysis." [1]

In their landmark 2008 review of forensic anthropology, Dirkmaat, Cabo, Ousley and Symes [1] extolled the extraordinary transformation forensic taphonomy had brought to the parent discipline. Indeed, the application of taphonomic principles from palaeontology and archaeology to increasingly complex questions arising from medicolegal death investigations "produced a revolutionary re-evaluation of the goals, perspectives, operating methods, range of work, and research potential in the field of forensic anthropology" [1]. The intervening decade has seen forensic taphonomy mature into a field in its own right, with a diverse and intensive research agenda based at an ever-increasing number of taphonomic research facilities. We have made huge strides in our understanding of decay; the multidisciplinary nature of forensic taphonomy providing us with a multi-lensed view of the process – from fundamental cellular dynamics to large-scale environmental interactions. Yet, despite unravelling many of decay's complexities, we have, thus far, fallen short of integrating our findings such that it illuminates the answers to the enduring questions of forensic taphonomy, most conspicuously, accurately estimating the post-mortem interval (PMI).

It's not for want of trying. In her 2017 critique of human taphonomy facilities, Professor Dame Sue Black highlights a 35-year endeavour to deduce this elusive answer [2]. Numerous works have contributed considerably to the field's determined, legal obligation-driven pursuit to quantify the decomposition process. Despite the promise of the resultant PMI estimation methods, mixed success from geographically disparate validation studies illustrates a failure in one of the core criteria for practical relevance of PMI estimation methods: "…proof of precision on independent materials" [3] – something that has dogged all taphonomy-based methods to date, whether derived from human study or animal analogues. Is it possible that we are asking the wrong questions, or have unrealistic expectations, as contemplated by Black [2]? We would argue, respectfully, that perhaps it is not the questions which require reconsideration at this stage, but the methods we are using to try and answer them.

As Dirkmaat et al. [1] emphasised, forensic taphonomy's methods and principles of data collection in experimental research are among its strongest contributions to forensic anthropology. The discipline has done well to apply progressively rigorous scientific methodologies to the investigation of very complex ecosystems. For example, multi-carcass deployments with controlled biographical parameters and non-experimental controls, aimed at improving the statistical robusticity of inferences drawn from results, are standard practice in contemporary experimental taphonomic research. However, as has been increasingly pointed out, a lack of standardization is hobbling our ability to compare notes. The narrow scope of many taphonomic investigations and variations in resource availability have not helped, either. Reductionism has served the discipline well thus far, but the development of a comprehensive model of decay with predictive power requires synthesis: integration of high-resolution data from a wide array of variables implicit in the decomposition ecosystem, across varied biogeographic circumstances. These are proving difficult to obtain with current data collection techniques. Indeed, in her recent perspective article reviewing one of the most promising contemporary PMI estimation techniques, “microbial clocks”, Metcalf [4] laments the low resolution of data imposed by current data collection techniques and highlights it as a knowledge gap that needs to be addressed. There are only so many variables which can be manually monitored or collected simultaneously in any given circumstance, made impossible to achieve without incurring a potentially prohibitive increase in labour and the associated costs when in-study replication is concerned – something our own research team has continually grappled with. Indeed, it could be argued the pervasiveness of this issue warrants its addition to Marshall’s [5] list of hindrances to taphonomy – all of which continue to plague the discipline 30 years later [6]. Faced with this problem, we asked a simple question: how can we reduce the cost of collecting data, especially with replicates, without sacrificing data resolution? Further contemplation crystallised it: how do we achieve simultaneous, high-resolution quantifiable monitoring of diverse variables in a standardised fashion within individual decomposition circumstances with low cost and high reliability? Our proposition is automation of data collection.

Automation is not new. It has revolutionised major industries including manufacturing, automotive and agriculture. However, the reduction in scale and cost of micro-computing technologies (e.g. Arduino® and Raspberry-Pi®) – one of the great gifts of the Fourth Industrial Revolution – has opened the technology up to a much wider swathe of users. Indeed, some aspects of contemporary forensic research already enjoy automation to varying degrees, particularly where lab-based microbiological, genetic, and chemical investigations are undertaken. Here, automation is streamlining and optimizing laboratory protocols and facilitating processing of larger and more complex datasets. Regrettably, these fields, alongside forensic taphonomy, have been slow to take up the technology in field-based experimentation.

Long-term cost reduction and continuous systems-monitoring with central management and processing are two core benefits the introduction of automation to taphonomic research could bring. Both are sorely needed if we are to achieve the standardisation of data collection and increased statistical rigor, quantitative measurement of variables and mathematical description of results demanded by science and the courts [2,3]. We are not merely imagining this: at the time of writing our research team has completed the second field test of a prototype automated weighing system for quantifying carcass mass loss as a measure of decomposition progression – the first of its kind, to the best of our knowledge, to be reported worldwide. The next phase of this project will see the integration of multiple streams of data which are currently autonomously, but independently, collected, with remote off-site transmission via GSM (Global System for Mobile Communications) network and incorporation into a central database. Currently, only weight loss data are transmitted off-site. The centralised dataset will then be processed and analysed using pre-written scripts and algorithms which are in development. Through further optimization and development, we envision a modular, scalable apparatus which can be tailored to any taphonomic investigation, whether investigating a particular process, or establishing regional baseline data. Technological advancement has given us the range of sensors required to monitor the minutiae of taphonomic processes, whilst the advent of the tools of modern data science – artificial intelligence, machine-learning and high-throughput computing – has provided us with sufficiently powerful and complex processing to manage the “big data” derived from such experiments. Indeed, Metcalf [4] highlights the benefits of implementing machine-learning for processing the large, complex datasets generated by current research into the decomposition microbiome.

We propose that automation technology *paired* with modern data science tools such as machine learning could help address the pressing issues in forensic taphonomy underscored above. By simultaneously monitoring a wider array of variables in a standardized fashion, we stand to improve our understanding of the nuanced and elaborate interactions between the many players in the decomposition ecosystem. This would be a major step towards the much called for development of sound taphonomic theory founded in carrion ecology theory, as well as, help address the requirement to quantitatively take influencing factors into account [3]. Moreover, implementation of such systems in taphonomic research on both human and animal analogues could contribute considerably to informing the deliberation around the appropriateness of the latter as research subjects. Finally, standardized, but modular, scalable and customizable, data collection will facilitate the establishment of large, coordinated multi-biogeographical studies as rightly called for by Metcalf [4]. The technology may also improve the efficacy and efficiency of existing field data collection methodologies such as photogrammetry. Of course, such an enterprise cannot be accomplished by forensic anthropologists or taphonomists, alone. It will require synergistic research groups with diverse, transdisciplinary expertise, not unlike our own group which presently includes expertise in electrical engineering, bioarchaeology, forensic anthropology, forensic taphonomy, forensic entomology, and zoology, and is set to diversify further as the team grows.

Doubt in our discipline’s ambitious goals is knocking at the door. In this sink-or-swim moment, we may be on the cusp of the next major advancement of our discipline. Will we grasp this golden ticket we’ve been offered? The clarion calls have gone out for solutions to the hindrances associated with standardisation, quantification, increased regional comparative datasets, theory development, and enhanced transdisciplinary cooperation. This, in brief, is how we propose responding. Do you agree?

Conflict of Interest: The authors declare that they have no conflict of interest.

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