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SPECIAL FEATURE: Species Limits and Taxonomy in Birds

Avian taxonomy in turmoil: The 7-point rule is poorly reproducible and may overlook substantial cryptic diversity

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ABSTRACT

The ornithological world has 4 global checklists (as of early 2020). While 3 follow the results of peer-reviewed research at varying pace and conservatism, the HBW/BirdLife checklist, which is adopted by the global Red List authority, has implemented Tobias et al.'s (2010) 7-point scoring system to overhaul global ornithological treatment. Critically received in some academic quarters, this scoring system is lauded by other ornithologists for its simplicity and reproducibility, a claim that remains to be tested. We subjected 26 ornithologists to a set of 48 bird skins belonging to 20 controversial taxonomic complexes and observed a wide variance in scoring results, in most cases straddling anywhere from far below to above the species threshold of the 7-point rule and casting doubt on claims of high reproducibility. For a detailed assessment of genuine taxonomic discord, we compared the taxonomic coverage of the avifauna of the Indonesian Archipelago (comprising ~1,400 species) between the HBW/BirdLife checklist, other major authorities, and the peer-reviewed literature. We detected that controversial treatments supported by the 7-point rule but at odds with the peer-reviewed literature predominantly refer to lumps, not splits, which are the usual subject of modern taxonomic quarrels. Notably, the method tends to unite morphologically (and sometimes vocally) cryptic forms into single larger species because of its inability to accommodate molecular and massive bioacoustic datasets that would indicate otherwise. On the other hand, the 7-point rule has produced numerous novel proposals for splits that may or may not be corroborated by future peer-reviewed inquiry. We recommend the 7-point rule as one of the multiple unofficial exploratory tools to flag cases of potentially cryptic species requiring further inquiry, but we advise against its adoption by other taxonomic authorities and the ornithological community.

Keywords: bird classification, checklists, reproducibility, taxonomic incongruence, Tobias criteria

LAY SUMMARY

- Competing authorities continue to be in ample disagreement about birds' classification.
- The checklist that Birdlife International applies to the global Red List is unique in that a standardized scoring system, the 7-point rule, was adopted to overhaul taxonomic treatments, often overturning the results of peer-reviewed research.
- We explored the magnitude of conflict generated by application of the 7-point rule. Novel treatments disagreeing with peer-reviewed publications predominantly referred to "lumps," with some cryptic forms united into single species because of the method's inability to accommodate molecular and massive bioacoustic datasets.
- We also subjected 20 controversial cases to 7-point scoring by 26 ornithologists and observed a wide score variance, straddling from far below to above the 7-point species threshold and casting doubt on claims of high reproducibility.
- We recommend against the adoption of the 7-point rule by taxonomic authorities, although it may continue to be a good informal approach to flag potential splits.

Taxonomía aviar en crisis: La regla de los 7 puntos es poco reproducible y puede pasar por alto una diversidad críptica sustancial

RESUMEN

El mundo ornitológico tiene cuatro listas de verificación globales (a inicios de 2020). Mientras tres siguen los resultados de investigación revisada entre pares a diferente ritmo y conservadurismo, la lista de verificación de HBW/BirdLife, que es adoptada por la autoridad global de la Lista Roja, ha implementado el sistema de puntuación de 7 puntos de Tobias et al. (2010) para revisar el tratamiento ornitológico global. Recibido de modo crítico en algunos centros académicos, este sistema de puntuación es alabado por otros ornitólogos por su simplicidad y reproducibilidad, una afirmación que

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debe ser probada. Presentamos ante 26 ornitólogos un conjunto de 48 pieles de aves pertenecientes a 20 complejos taxonómicos controversiales y observamos una amplia variación en los resultados de su puntuación, en la mayoría de los casos fluctuando desde muy por debajo hasta por encima del umbral de la especie usando la regla de los 7 puntos y poniendo en duda las afirmaciones de alta reproducibilidad. Para una evaluación detallada de una discordia taxonómica genuina, comparamos la cobertura taxonómica de la avifauna del Archipiélago Indonesio (que comprende ~1,400 especies) usando la lista de verificación de HBW/BirdLife, de otras autoridades principales y la literatura revisada entre pares. Detectamos que los tratamientos controversiales apoyados por la regla de los 7 puntos, pero en desacuerdo con la literatura revisada entre pares, predominantemente se refiere a agrupaciones, no divisiones, que son el tema habitual de las disputas taxonómicas modernas. Notablemente, el método tiende a unir formas morfológicas (y a veces vocales) crípticas en especies únicas más grandes debido a su imposibilidad de acomodar bases de datos moleculares y bio-acústicas masivas que indicarían lo contrario. Por otro lado, la regla de los 7 puntos ha producido numerosas propuestas nuevas de divisiones que pueden o no ser corroboradas por futuras investigaciones revisadas entre pares. Recomendamos la regla de los 7 puntos como una de múltiples herramientas exploratorias no oficiales para señalar casos de especies potencialmente crípticas que requieren más investigación, pero desaconsejamos su adopción por otras autoridades taxonómicas y por la comunidad ornitológica.

Palabras clave: clasificación de las aves, criterio de Tobias, incongruencia taxonómica, lista de verificación, reproducibilidad

INTRODUCTION

The State of Global Bird Taxonomy

Bird taxonomists of the late 20th and early 21st centuries have witnessed the advent of modern bioacoustic quantification methods and the integration of gene-wide and then genome-wide DNA sequence datasets. The major new insights resulting from these developments have kindled hope of stabilization of global bird taxonomy. Yet reality has unfolded differently: Our field has seen a relatively stable global classification of birds in the 1960s and 1970s give way to widespread discord, with a distinct lack of alignment among multiple competing global checklists as well as leading regional treatises.

Avian taxonomy throughout much of the 20th century was dominated by the *Checklist of the Birds of the World*, a series of 16 volumes often known as "Peters' Checklist" for the disproportionate contributions by its conceiver James Lee Peters (Peters 1931, 1934, 1937, 1940, 1945, 1948, 1951, Mayr and Greenway 1960, Amadon et al. 1962, Deignan and Ripley 1964, Greenway et al. 1967, Blake et al. 1968, Paynter and Storer 1970, Amadon et al. 1979, Mayr and Traylor 1986, Paynter 1987). Toward the end of the 20th century, the introduction of modern DNA sequencing technology (Sanger and Coulson 1975, Maxam and Gilbert 1977, Rubin and Schmid 1980) and its application in a population-genetic and phylogenetic framework occurred almost simultaneously with a revolution in the way that quantitative bioacoustic data are incorporated in avian taxonomic work (Alström and Ranft 2003). These 2 significant developments have precipitated an avalanche of new insights, leading to the re-drawing of species boundaries across a significant portion of bird genera.

With differences in researchers' proclivity to embrace new data or remain conservative, the field has seen a splintering of taxonomic opinion. By the beginning of 2020, the following 4 principal avian checklists of the birds of the world had crystallized (in no particular order): (1) the *Howard & Moore Complete Checklist of the Birds of the World*, now in its fourth edition (Dickinson and Remsen 2013, Dickinson and Christidis 2014); (2) the *IOC World Bird List* (Gill and Donsker 2018), which is currently being updated twice a year; (3) the *eBird/Clements Checklist of Birds of the World* (Clements et al. 2019), which originated from the *Clements Checklist of Birds of the World* (Clements 2007) and was purchased and continues to be implemented by the Cornell Lab of Ornithology after J.F. Clements's death; and (4) the HBW/BirdLife *Taxonomic Checklist*, now in its third version (del Hoyo et al. 2020), derived from 2 hardcopy volumes that make up the *HBW and BirdLife International Illustrated Checklist of the Birds of the World* (del Hoyo and Collar 2014, 2016).

The HBW/BirdLife Checklist and the 7-Point Rule

Although minor disagreements will always arise, a harmonization of the taxonomy of the world's birds should be the automatic eventual outcome if all checklists follow one and the same *modus operandi*—that is a gradual and stepwise integration of the scientific consensus of peer-reviewed, evidence-based publications in taxonomic decision-making. Only one checklist has stood out in the implementation of its own protocol: The HBW/BirdLife checklist has undertaken a comprehensive overhaul of global bird species classification by subjecting controversial taxonomic comparisons to the outcome of a quantitative species delimitation method referred to as the Tobias test or the "7-point rule" (Tobias et al. 2010).

This 7-point rule is a simple, intuitive scoring test that tallies phenotypic differences depending on whether they are perceived to be minor (1 point), medium (2 points), major (3 points), or exceptional (4 points). To the best of our knowledge, the test is unable to deal with molecular data. On the other hand, it is said to accommodate bioacoustic data in the same way it does

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mensural or other morphological characters, although by far most applications of this test have been carried out on plumage and biometrics thus far. The 7-point rule is described by its inventors (Tobias et al. 2010) as following the tenets of the Biological Species Concept (Mayr 1942), although fundamental conflicts between the 2 have been exposed and discussed in detail, leading to a widespread characterization of the 7-point rule as a phenetic or typological species delimitation concept (see below; Remsen 2015, Sangster 2018). The 7-point rule entails various safeguards to preclude the tallying of non-independent character sets and draws species boundaries in taxon comparisons that reach a score of 7 or above, while retaining taxa within one species if they only reach 6 points or fewer.

Beyond its application in the context of the HBW/BirdLife checklist or in publications by the authors of the work (Tobias et al. 2010), the 7-point rule has been utilized by a varied but limited set of additional authors, often to confirm taxonomic proposals supported through independent avenues of inquiry (Rheindt et al. 2011, Rasmussen et al. 2012, Fernando et al. 2016, Fischer et al. 2018). The 7-point rule has not been embraced as a routine taxonomic arbiter by any of the other major global checklists, any regional taxonomic authority, or any newly published regional field guide, except most of those books produced by the same publishing house as HBW and directly based on HBW's drawings and taxonomy.

Critics have deplored the wholesale adoption of the premises of the 7-point rule on the basis of a variety of concerns (Remsen 2015, Sangster 2018), important of which are the following 3 concerns: (1) its unusual and arguably contradictory interpretation of various geographic modes of overlap (e.g., parapatry; sympatry with or without hybridization) as either supportive or unsupportive of species status, including a discard of direct biological evidence of species status (e.g., lack of interbreeding in sympatry) in favor of test score results; (2) its all-encompassing use of 7 points—calibrated by means of a limited set of example groups—as an appropriate threshold across the entire spectrum of modern Aves ranging from taxonomically straightforward lineages (e.g., *Calyptomena* broadbills) to those that may be both visually and bioacoustically cryptic (e.g., *Microptilotis* honeyeaters, *Muscicapa* flycatchers); (3) its regression to a phenetics-based taxonomic philosophy—long since abandoned by biologists—grounded in the premise that absolute character differences reflect relationships and taxonomic status.

Quantifying taxonomic discord generated by the 7-point rule. The wide-ranging overhaul of global bird species taxonomy in the HBW/BirdLife checklist has relied on an extensive—albeit incomplete—application of the 7-point rule to controversial taxonomic cases (del Hoyo and Collar 2014, 2016). This exercise has led to numerous novel splits hitherto overlooked in the literature (462 in non-passerines alone; Remsen 2015), but also to an unquantified number of treatments contradicting or overthrowing previous taxonomic decisions that had followed the conclusions of evidence-based scientific studies. Given that the HBW/BirdLife checklist happens to be the one whose taxonomy is applied by the global Red List authority (IUCN in collaboration with BirdLife), it is particularly urgent to assess the magnitude of this taxonomic incongruence.

Assessing the level of disagreement between the HBW/BirdLife checklist, other checklists, and the peer-reviewed literature would have been too extensive for the entire global avifauna. Hence, we focused on one well-defined region that we happen to know well, the Indonesian Archipelago (as circumscribed by Eaton et al. 2016), with roughly 1,400 species, to quantify the magnitude of taxonomic discord between the HBW/BirdLife checklist, in particular its novel treatments based on the 7-point rule, with other general checklists and with the peer-reviewed literature.

It is important to note that the purpose of this exercise is not to pass taxonomic judgment on each conflicting classification. There may well be cases in which HBW/BirdLife's treatment more closely reflects biological reality and will prevail with future additional research, whereas conclusions in the current peer-reviewed literature may be based on insufficient or faulty data. Case-by-case assessment is necessary to gauge the specific merits of the HBW/BirdLife treatment in each of those flagged species complexes. But our mapping of controversial taxonomy does allow us to characterize the general nature of such cases of disagreement and detect underlying patterns that may highlight specific shortcomings of the 7-point rule.

Assessing the level of reproducibility of the 7-point rule. Del Hoyo and Collar (2014, 2016) maintain that 2 main attributes render the 7-point rule the method of choice for a wholesale taxonomic reassessment of the world's birds: its ease of applicability and its reproducibility. The former attribute is generally uncontested even by critics, although it has been pointed out that the ease of applicability says nothing about the rigor of a method or the truth value of its results (see especially Sangster 2018). However, the question of whether 7-point rule assessments are highly reproducible has not been addressed in great detail. We have carried out a controlled experiment, presenting 48 well-preserved museum skins from across the Indonesian Archipelago belonging to 20 bird species complexes with a history of controversial taxonomic treatment, and subjecting them to "7-point rule" scoring by 26 ornithologists with diverse

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backgrounds and levels of expertise to assess the degree of reproducibility of the method.

METHODS

Compiling Taxonomic Incongruence Involving the 7-Point Rule

We identified cases of differential taxonomic treatment potentially produced by the application of the 7-point rule by comparing discrepancies in species classification between the HBW/BirdLife checklist (del Hoyo et al. 2020) and the original volumes of the *Handbook of the Birds of the World* (del Hoyo et al. 1992, 1994, 1996, 1997, 1999, 2001, 2002, 2003, 2004, 2005, 2006, 2007, 2008, 2009, 2010, 2011), which had been published between 1992 and 2011 and were not originally subject to 7-point scoring. The taxonomic treatment of all species complexes thus identified was then compared between the HBW/BirdLife checklist and the following 4 sources: (1) eBird/Clements Checklist, (2) Howard & Moore Checklist, (3) IOC Checklist, and (4) Eaton et al.'s (2016) *Birds of the Indonesian Archipelago*. To ensure that we include notable cases of unusual taxonomic treatment by HBW/BirdLife in which their checklist and their serial book volumes followed identical classifications (especially toward the later HBW volumes), we also added cases of taxonomic disagreement between HBW/BirdLife and the regional field guide (Eaton et al. 2016), comparing them with the treatments afforded by all of the other 3 checklists (see above). Eaton et al.'s (2016) field guide was only used to flag such cases and was not used as a taxonomic arbiter of preferential treatment. Finally, we compiled all flagged cases of disagreement (total of 452; Supplementary Material 1: Table S1) and gathered a comprehensive list of peer-reviewed studies that involved the relevant taxa published through May 2019.

Each case of taxonomic disagreement was assigned a category (Box 1; Supplementary Material 1: Tables S1–S3), principally along the lines of whether HBW/BirdLife carried out a lump (uniting ≥2 species into one) or a split (dividing a species into ≥2). More importantly, these lumps and splits were categorized according to whether (1) they follow majority consensus among global checklists or are supported by the peer-reviewed literature (categories 1–3; Box 1); (2) they are contradicted by conclusions drawn on the basis of the peer-reviewed literature (categories 4–8; Box 1); or (3) they are novel and remain to be tested in the scientific taxonomic arena (categories 9–11; Box 1). There was a limited number of taxonomic cases addressed by multiple peer-reviewed studies whose evidence was not in complete agreement with one another. In these cases, we always followed the conclusions of the study that either contained a clearly more compelling dataset, or—if in doubt—the consensus of the majority of available studies and checklists.

Testing the Reproducibility of the 7-Point Rule

For an evaluation of the reproducibility of 7-point assessments, we recruited a panel of 26 ornithologists and subjected them to a test set of 48 bird skins of species occurring across the Indonesian Archipelago (henceforth: the specimen survey). The specimens examined belonged to 18–20 species complexes housed in the Lee Kong Chian Museum of Natural History in Singapore (Supplementary Material 1: Table S4 and Figure S1). All 18–20 complexes are characterized by a history of controversial taxonomic treatment (hence their number can be characterized as anywhere between 18 and 20; Supplementary Material 1: Table S4) and were spatially arranged to facilitate 27 taxonomically relevant pairwise comparisons. For species in which bioacoustic traits have been proposed to be taxonomically relevant, homologous sound recordings representative of all vocalizations of taxonomic significance were played on demand, and sonograms representative of each skin were displayed during scoring sessions (Supplementary Material 1: Table S5; Supplementary Material 2). If relevant from a 7-point rule perspective, participants were provided with additional information on the ecology and geographic distribution of taxa (Supplementary Material 1: Figure S1).

All ornithologists who were tested underwent the same instruction session and were briefed on the exact criteria of the 7-point rule. The test subjects were from varied ethnic backgrounds and nationalities and comprised a roughly equal gender representation (12 female and 14 male participants). Participants included persons from the USA, 3 European countries, and 3 Asian countries, representing different age and career stages ranging from the young 20s to the late 40s. To account for variation, our panel of ornithologists had a wide background of expertise (Supplementary Material 1: Table S6). Specifically, participants were scored based on 3 quantitative criteria: (1) Number of peer-reviewed ornithological papers authored at the time: 9 participants had published ≥3 papers, another 4 had published one, and the remainder had not published papers thus far. These figures reflect the early career stage of some participants. (2) An average number of days per month spent in the field performing serious birdwatching (with binoculars or other equipment) or comparable ornithological field activities in 2018 (until October 31, 2018): 14 persons had spent >4 days per month in the field, and 9 had spent at least 2–4 days per month in the field, reflecting our panel's experience in judging characters of taxonomic importance. (3) Number of countries in which ornithological fieldwork or serious birdwatching activities had been conducted: 19 out of 25 participants had experience

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Box 1. Assignment categories for cases of taxonomic disagreement between the HBW/BirdLife checklist and other taxonomic sources (see Methods). Categories 1–3 (in non-bold) comprise cases of flagged taxonomic disagreement in which the HBW/BirdLife checklist nevertheless followed the majority treatment adopted by most other authorities, sometimes (where available) additionally supported by the peer-reviewed literature. Categories 4–8 (in **bold**) include cases of disagreement in which the peer-reviewed literature presents opposing taxonomic recommendations to the treatment adopted by the HBW/BirdLife checklist. Categories 9–11 (in non-bold) comprise cases of taxonomic disagreement in which the HBW/BirdLife checklist adopts a novel treatment hitherto not proposed in the modern literature that remains to be tested in the scientific arena. The final category (12, in non-bold) is one in which the HBW/BirdLife checklist appears to flag potential splits only to indicate past treatments that it disregards as erroneous; the latter category was not included in the total count of cases of disagreement.

(1) "Lump—Agree" was assigned when HBW/BirdLife implemented a lump of ≥2 former species into one, but that lump had equally been implemented by at least half of the other 4 sources or has been supported by the peer-reviewed literature.

(2) "Split—Agree" was assigned when HBW/BirdLife implemented a split in what used to be a single species, but that split had equally been implemented by at least half of the other 4 sources or has been supported by the peer-reviewed literature.

(3) "Limbo—Agree" was assigned when HBW/BirdLife flagged potential splits through its colored bullet point system, but these were simultaneously flagged as potential splits by at least one other taxonomic source or fully split by up to one other source, with no good peer-reviewed evidence pointing either way.

(4) **"Lump—Disagree despite 7PR" was assigned when HBW/BirdLife explicitly united ≥2 species into one as a consequence of the application of the 7-point rule, even though the peer-reviewed literature presents evidence to the contrary.**

(5) **"Lump—Disagree without 7PR" was assigned when HBW/BirdLife explicitly united ≥2 species into one without demonstrably having applied the 7-point rule, even though the peer-reviewed literature presents evidence pointing to a split. HBW/BirdLife may have omitted summary data on the application of the 7-point rule in cases that did not reach the 7-point threshold. Therefore, some of the cases classified under this category may instead belong to category 4.**

(6) **"Limbo—Disagree" was assigned when HBW/BirdLife flagged potential splits through its colored bullet point system despite the peer-reviewed literature presenting firm evidence either for or against a split, arguing against the application of the colored bullet point system to indicate uncertainty.**

(7) **"Split—Disagree despite 7PR" was assigned when HBW/BirdLife explicitly split a species into ≥2 daughter species as a consequence of the application of the 7-point rule, even though the peer-reviewed literature presents evidence to the contrary.**

(8) **"Split—Disagree without 7PR" was assigned when HBW/BirdLife explicitly split a species into ≥2 daughter species without demonstrably having applied the 7-point rule, even though the peer-reviewed literature presents evidence to the contrary. It is unclear whether some of these are cases in which HBW/BirdLife actually applied the 7-point rule but did not present the summary data.**

(9) "Split—Novel" was assigned to cases in which HBW/BirdLife implemented a split that had not been carried out by any of the other 4 sources, and for which peer-reviewed evidence remains lacking.

(10) "Lump—Novel" was assigned to cases in which HBW/BirdLife implemented a lump of ≥2 well-established species into one, provided that this lump had not been carried out by any of the other 4 sources and that peer-reviewed evidence remains lacking.

(11) "Limbo—Novel" was assigned to cases in which HBW/BirdLife used its colored bullet point system to flag potential splits that have not been flagged by any other source, with peer-reviewed evidence lacking.

(12) "Limbo—Flag Unlikely Treatment" was assigned to cases in which HBW/BirdLife implies that their use of the colored bullet point system was merely to flag past and discarded treatments. We do not interpret these cases as actual disagreements between HBW/BirdLife and other sources.

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in ≥5 countries, reflecting their close familiarity with a wide variety of global bird families.

RESULTS

Among the 452 flagged cases in which the HBW/BirdLife Checklist differed in taxonomic treatment from either the regional field guide or from the previous HBW book series, we detected 256 (i.e. ~57%) in which HBW/BirdLife's taxonomic treatment was deemed to be in broad agreement with other checklists or with the peer-reviewed literature or both (see categories 1–3 in Box 1; Supplementary Material 1: Tables S1–S3). Another 77 flagged cases (~17%) referred to novel treatments by HBW/BirdLife—most often novel splits—that were generally not reflected by other sources, while peer-reviewed publications on these species complexes are not available (see categories 9–11 in Box 1; Supplementary Material 1: Tables S1–S3).

Finally, 119 cases (~26%) were found to be in disagreement with the results of peer-reviewed research. Thirty-six, amounting to almost a third of the conflicting 119 cases, refer to lumps, while only 17 refer to splits (see categories 4–5 and 7–8 in Box 1; Supplementary Material 1: Tables S1–S3). The remainder of these conflicting cases are so-called "limbo splits," that is, a special category of potential splits flagged by HBW/BirdLife via a colored bullet point system (category 6 in Box 1).

Our scoring exercise with the volunteer panel of ornithologists revealed extensive variation in final scores across participants (Figure 1). Among the 27 pairwise taxon comparisons, 17 (i.e. ~63%) had final score profiles with confidence intervals that straddle either side of the 7-point threshold (Figure 1; Supplementary Material 1: Table S7). The greatest variance was generally found in plumage scores, but also—at a less pronounced level—in bioacoustic scores for species complexes in which vocalizations are taxonomically important (Figure 1). Even in those complexes characterized by the smallest scoring variance within our experiment (especially *Zosterops* white-eyes), final tallies routinely differed by more than 3 points, whereas in most other species complexes, final score differences of 5–7 points were not unusual (Figure 1; Supplementary Material 1: Table S7).

DISCUSSION

Assessing Taxonomic Conformity of the HBW/BirdLife Checklist

Out of the 452 flagged taxonomic cases, 77 (~17%) constituted novel treatments by HBW/BirdLife—most often novel splits not implemented by any other taxonomic authority (see categories 9–11 in Box 1; Supplementary Material 1: Tables S1–S3). This outcome is not inconsistent with the claim that the 7-point rule may be a good tool to flag cases of potential cryptic speciation or taxonomic neglect (Tobias et al. 2010), which are especially prevalent in tropical Asia (Collar 2003). Given the absence of independent evidence, these cases remain to be validated by future research and do not feature in our quantitative assessment of taxonomic discord generated by the 7-point rule.

More than a quarter (i.e. 119) of the 452 flagged taxonomic cases were found to be in disagreement with the results of peer-reviewed research. This is a substantial number, given that the overall number of 452 cases may have been inflated by our sensitive flagging practices (see below). More than half of these 119 cases (i.e. 66, or ~55%) refer to so-called "limbo splits," that is, a special category of potential splits flagged by HBW/BirdLife via a colored bullet point system (category 6 in Box 1). It is unclear how prominently the application of the 7-point rule has featured in the proposal of most limbo splits, as HBW/BirdLife does not disclose whether a lack of information on point tallying indicates that the 7-point test was not carried out at all, or whether it had failed the 7-point threshold. If the 7-point rule played a large role in advancing so many limbo splits that emerge as unsupported by the peer-reviewed literature, it would raise concerns about the test's general value and reliability. For now, we feel it is best to ignore "limbo splits" in this discussion given the uncertainties regarding the role of the 7-point rule in their advancement.

More than half (i.e. ~57%) of the 452 flagged cases emerged as uncontroversial and in broad agreement with other modern sources, including the primary scientific literature (see categories 1–3 in Box 1; Supplementary Material 1: Tables S1–S3). While this high percentage may create the impression that the 7-point rule has a substantial degree of conformity with peer-reviewed taxonomic research, it is important to consider that many of these cases would have already constituted "mainstream taxonomy" at the time of the HBW/BirdLife checklist's publication. Given our practice of flagging even minor incongruences, our total number (452 cases) is likely inflated by including numerous taxonomic treatments that may have been controversial a few years ago but have—by now—been widely accepted, often on the basis of independent peer-reviewed research. Moreover, a substantial proportion of these 452 cases may not have been subjected to 7-point scoring at all. Unfortunately, this is difficult to ascertain with certainty as test scores are only selectively provided in the checklist.

The 7-point rule has produced more controversial lumps than splits. There were more than twice as many HBW/BirdLife lumps than splits that stood in conflict with the peer-reviewed literature (36 vs. 17; see categories 4–5 and 7–8 in Box 1; Supplementary Material 1: Tables

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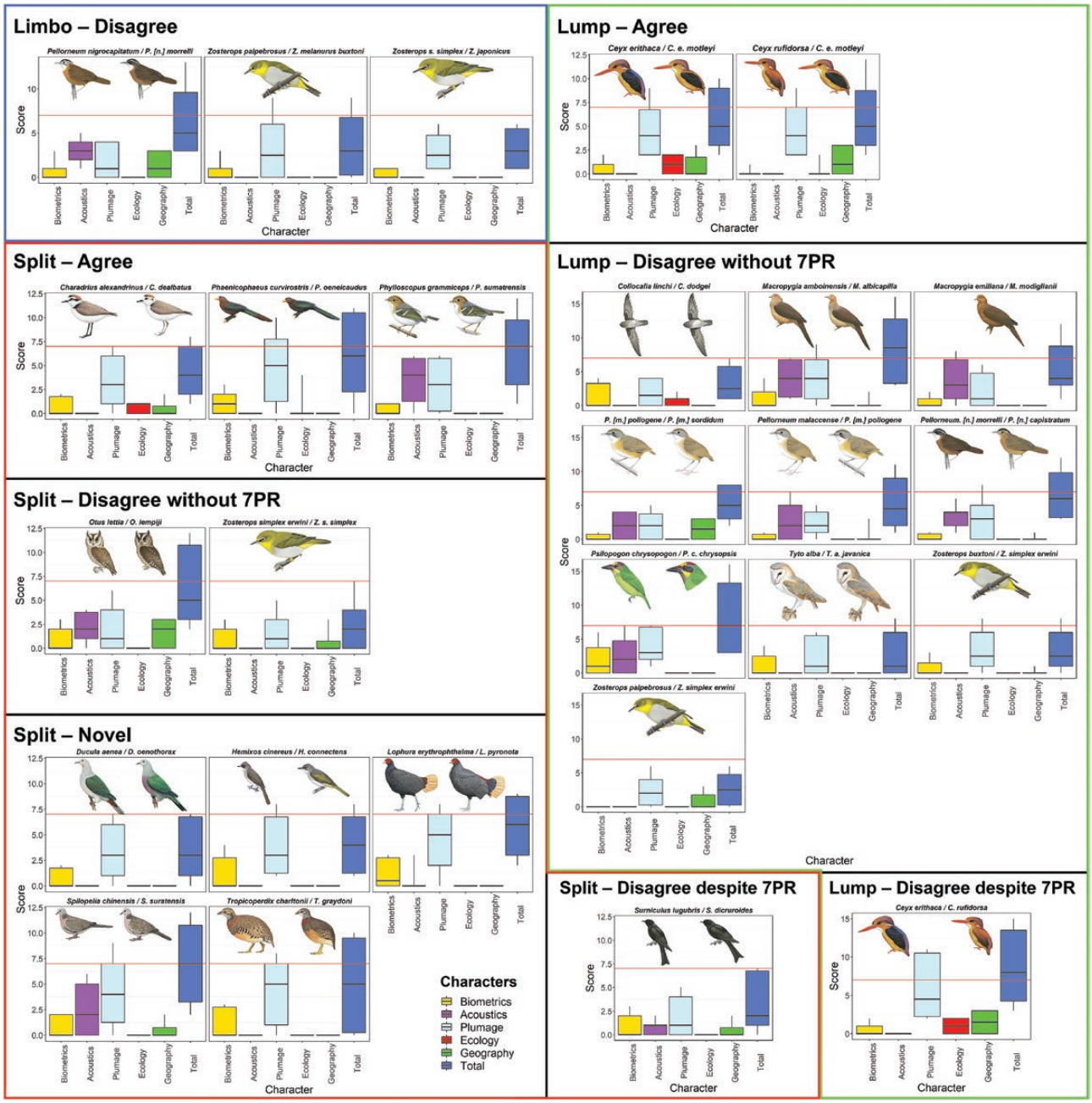

FIGURE 1. Box plots with 90% interquartile ranges of 7-point rule scores assigned by the 26 volunteer ornithologists to assess taxonomic rank across all 27 relevant pairwise taxon comparisons. Within each pairwise taxon comparison, individual boxplot scores are given for differences in biometrics, vocalizations, plumage, ecology, and distribution mode, followed by the total score. The 7-point species threshold is marked with a red horizontal line in each boxplot graph. Headers of the sub-panels (e.g., "Split—Agree" or "Limbo—Disagree") characterize the category of taxonomic disagreement between the HBW/BirdLife treatment and that of other sources following the classification given in Box 1.

S1–S3). Given that most modern taxonomic quarrels tend to revolve around novel splits, the high incidence of conflicting lumps is perhaps surprising and points to an overlooked phenomenon. We specifically scrutinized these lumps while remaining neutral with respect to the merits and quality of the peer-reviewed papers that presented opposing views.

The majority of the 36 conflicting HBW/BirdLife lumps refer to species groups in which plumage differences are minor, but in which vocalizations or courtship displays play an obviously important role as a pre-zygotic isolation mechanism (Supplementary Material 1: Tables S1–S3). In virtually all these cases, the application of the test fails to reach the 7-point species threshold in the absence of big

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score tallies of conspicuous plumage differences. While the opposing peer-reviewed conclusions are not always fully authoritative and additional research is warranted in some cases, there are good examples of species complexes under this category that have seen solid bioacoustic or genetic (sometimes even genomic) datasets making a strong case against the HBW/BirdLife lumps (Banks & Paterson 2007, Lim and Sheldon 2011, Peters et al. 2012, Ng et al. 2016, Gwee et al. 2017, Lim et al. 2017, Moyle et al. 2017, Garg et al. 2018, Lim et al. 2018).

Proponents of the 7-point rule may argue that the high incidence of problematic lumps is not a weakness of this method itself, but merely reflects the users' omission of important non-plumage data under the 7-point framework. Yet for most of these conflicting lumps, it is difficult to envisage scenarios in which the 7-point rule would have arrived at similar conclusions as the peer-reviewed literature, as the method does not appear amenable to including molecular data and has only been applied to modest bioacoustic datasets. While del Hoyo and Collar (2014, 2016) have included bioacoustic characters in a small minority of their 7-point applications, none of these rise to the rigor of modern bioacoustic datasets encompassing hundreds of individuals across 1–2 dozen sound parameters (Sangster and Rozendaal 2004, Ng et al. 2016), and it is unclear how such massive and detailed datasets would ever fit under the 7-point framework.

Conflicting HBW/BirdLife splits seem to be much less of a problem than lumps, both numerically but also when scrutinizing taxonomic circumstances. A good number among the 17 conflicting splits exhibit an equal taxonomic treatment between HBW/BirdLife and most other checklists, but surface as controversial in our compilation because of relatively new peer-reviewed research presenting evidence for a lump—whether compelling or not (Supplementary Material 1: Tables S1–S3). In some of these cases, the 7-point rule may not have been applied to begin with, as the authors of the HBW/BirdLife checklist seemed to focus their application of the 7-point rule toward achieving new splits, not new lumps. These findings corroborate that the 7-point rule's principal way of producing genuine taxonomic incongruence may be through lumps, not splits.

The small subset of conflicting HBW/BirdLife splits that were a verifiable product of 7-point scoring shared one commonality: the splits seem to hinge primarily on scores of >7 propelled by substantial biometric differences (e.g., *Gygis* [Yeung et al. 2009]; *Gelochelidon* [Tavares and Baker 2008]; Supplementary Material 1: Tables S1–S3). Size variation is generally known to be more important for ecological adaptation in the context of natural selection and less important for sexual selection in birds (Olson et al. 2009), highlighting the potential pitfalls of a phenetic approach in which differences from any character source, no matter how taxonomically relevant, are tallied up to a grand total.

Is the 7-Point Rule Reproducible?

The 7-point rule scores from the specimen survey displayed great disparity across the 26 participants (Figure 1; Supplementary Material 1: Table S7). Almost two-thirds of the 27 pairwise taxon comparisons (16 out of 26) were assigned tallies on either side of the 7-point species threshold, leading to disparate taxonomic conclusions among our panel of ornithologists. Even for comparisons in which most participants assigned a score below the 7-point threshold, variation is pronounced and often spans a range of scores around ~2–6, casting serious doubt on claims regarding high levels of reproducibility of the 7-point rule.

Our specimen survey entailed the comparison of single specimens for each taxon involved (with one exception; Supplementary Material 1: Table S4). Many modern specimen comparisons have recourse to larger series of specimens. Our specimen survey was not targeted to examine the actual taxonomic status of these birds, but merely the variance in score assignments among ornithologists, so the use of a single specimen per taxon would not have introduced any bias. To the contrary, it is reasonable to assume that the use of multiple specimens per taxon would have increased scoring variance, rendering the use of single specimens conservative by ensuring that the variance among test scores is not an artifact of the heterogeneity of specimen series, but truly reflects the 7-point rule's reproducibility.

The lowest scores (often zero) were generally assigned to characters in the "ecology" and "geography" criteria. This is a true reflection of the incidental lack of strong taxon differences in these categories among the example species chosen. Relevant ecological and geographic differences cannot be displayed in a museum skin and were provided through written hints, possibly creating a bias. If such bias was indeed present, it would have skewed our results to become more conservative, as additional sources of scoring variation would thereby have been removed.

The highest scoring differences invariably related to plumage and—where relevant—bioacoustics, much less so to biometrics (Figure 1). Specifically, some of the largest variances in plumage scoring were found in species complexes whose members are set apart by multiple smaller color differences. Disagreements in final scores were largely attributable to 2 problems introducing subjectivity into 7-point assessments: (1) Subjective differences over whether to afford minor (1 point), medium (2 points), or major (3 points) scores to any of a handful of smaller color differences between 2 taxa (Supplementary Material 1: Table

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S7): The magnitude of any particular color difference is often in the eye of the beholder. Score discrepancies quickly add up across multiple plumage characters within a comparison, despite cutoffs in the system limiting the number of traits allowed to enter the final score from each assessment category. (2) Discrepancies in assessments of trait independence: Tobias et al. (2010) do not allow non-independent characters to be scored multiple times to preclude enrichment bias. But assessing the independence of different plumage traits is highly subjective, leading some practitioners to assign several smaller scores to multiple traits, while other practitioners regard them as one bigger composite difference. The latter practice may be a convenient subconscious strategy to inflate scores as multiple smaller scores will be affected by trait cutoffs built into the 7-point rule.

Our dataset contains multiple examples that illustrate these subjective biases in the scoring outcome. Pairwise comparisons within *Tropicoperdix* partridges, *Phaenicophaeus* malkohas, and *Spilopelia* doves each exhibit a 90% interquartile range spanning over a 6-point difference between participants in plumage scores alone (Figure 1), attesting to an immense variance in participants' subjective classification of differences as "minor" or not, and in their varying proclivity to combine several smaller but correlated color traits into one larger trait.

Plumage and vocalizations are the 2 most important categories in taxonomic applications of the 7-point rule. They also displayed by far the highest variances, with final score disparities of 3–6 points not uncommon between participants (Figure 1). These discrepancies indicate that the 7-point rule is susceptible to high levels of subjectivity and raises serious concerns about a wholesale reliance on the 7-point rule for global taxonomic decision-making.

Conclusions

As HBW/BirdLife's official species delimitation method, which is consequently adopted by the global avian Red List authority, the 7-point rule has assumed a prominent role in the taxonomic classification of birds over the last decade. This elevated position is perhaps in defiance of widespread resistance by the academic community to adopt it. The general level of incongruence between taxonomies that adopt and those that do not adopt the 7-point rule remains underexplored, and the oft-repeated claim of high reproducibility of the method has never been rigorously assessed.

Our test across 26 volunteer ornithologists revealed extensive levels of score variation, casting serious doubt on claims of reproducibility of the 7-point rule. Score variation was highest in the arguably most important character categories: plumage and bioacoustics. Most final scores ranged from anywhere far below to above the 7-point threshold within most pairwise taxon comparisons.

Using an Indonesian reference set of species, we found a distinct number of cases in which the 7-point rule converged on treatments in direct conflict with the peer-reviewed literature. The most troubling of these include a panel of morphologically conservative species in which the 7-point species threshold is impossible to reach on the basis of plumage alone, while the 7-point framework is unable to incorporate the results of molecular enquiry or massive bioacoustic datasets, thereby discarding evolutionary insights on gene flow and reproductive dynamics in favor of phenetic character scores.

We also found that HBW/BirdLife's application of the 7-point rule has flagged a relatively high number of novel splits, although the veracity of these splits remains to be determined in the absence of peer-reviewed studies. Therefore, we see the 7-point rule's main value in its use as one of multiple exploratory tools to flag interesting cases in need of taxonomic attention, often in terms of molecular and bioacoustic data generation. At the same time, we advise against an adoption of the 7-point rule by other taxonomic bodies and by the taxonomic community at large.

SUPPLEMENTARY MATERIAL

Supplementary material is available at *Ornithology* online.

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