Response to Comment on "Ivory-billed Woodpecker (*Campephilus principalis*) Persists in Continental North America"

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Claims that the bird in the Luneau video is a normal pileated woodpecker are based on misrepresentations of a pileated's underwing pattern, interpretation of video artifacts as plumage pattern, and inaccurate models of takeoff and flight behavior. These claims are contradicted by experimental data and fail to explain evidence in the Luneau video of white dorsal plumage, distinctive flight behavior, and a perched woodpecker with white upper parts.

Since obtaining the Luneau video (*1*), we have treated the southern pileated woodpecker (*Dryocopus pileatus pileatus*) as the null hypothesis for the bird's identity. We analyzed 56 videos of pileated woodpeckers launching and flying, and we tested the hypothesis experimentally with models. Numerous features of the bird differ substantially from those of the pileated woodpecker and match the ivory-billed woodpecker (*Campephilus principalis*), forcing us to reject the null hypothesis. We address the main points of Sibley *et al*. (*2*) here and present a comprehensive analysis of the Luneau video elsewhere (*3*).

The case presented by Sibley *et al*. (*2*) contains the following problems: (i) It relies on erroneous representation of the underwing of pileated woodpeckers as mostly white with a narrow black rim [figures 1C and S2 in (*2*) and recent field guides by the lead author (*4*)]. Pileated wings have more black than white on the ventral surface [see supporting online

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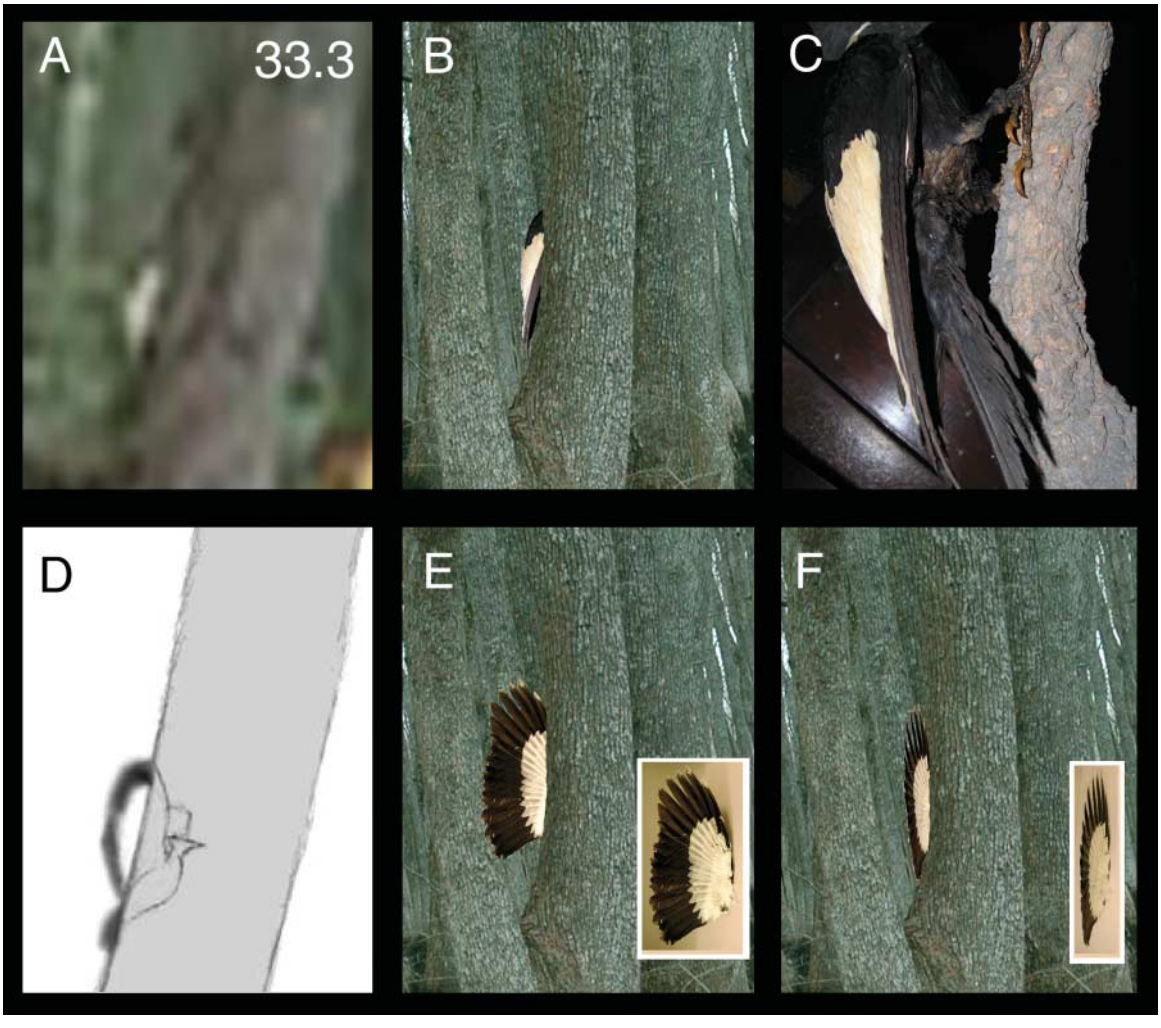

Fig. 1. Luneau video field 33.3 (**A**) shows the first major appearance of the woodpecker's right wing to the left of the tupelo trunk. The white triangle has black above and a small black spot between the lower edge and the trunk. We interpret this as a lateral view of the opening wing of an ivory-billed woodpecker as the bird begins to turn away from the approaching observers, matched here by a montage (**B**) of a specimen's wing (**C**) superimposed behind a tupelo trunk. Sibley *et al*. (*2*) propose, instead, that the pattern is a vertically extended underwing of a pileated woodpecker (**D**), but comparison with a pileated woodpecker wing specimen at such an angle (**E**) reveals flaws in their diagram. A pileated woodpecker wing would show a broad black border entirely encircling the white and comprising 60 to 70% of the wing area. If the wing were tilting away from or toward the viewer, thus showing less black, the white underwing also would be extremely narrow (**F**). Moreover, the position of the tail and body proposed by Sibley *et al*. (*2*) in this field are incompatible with the sequence of movement observed in adjacent frames.

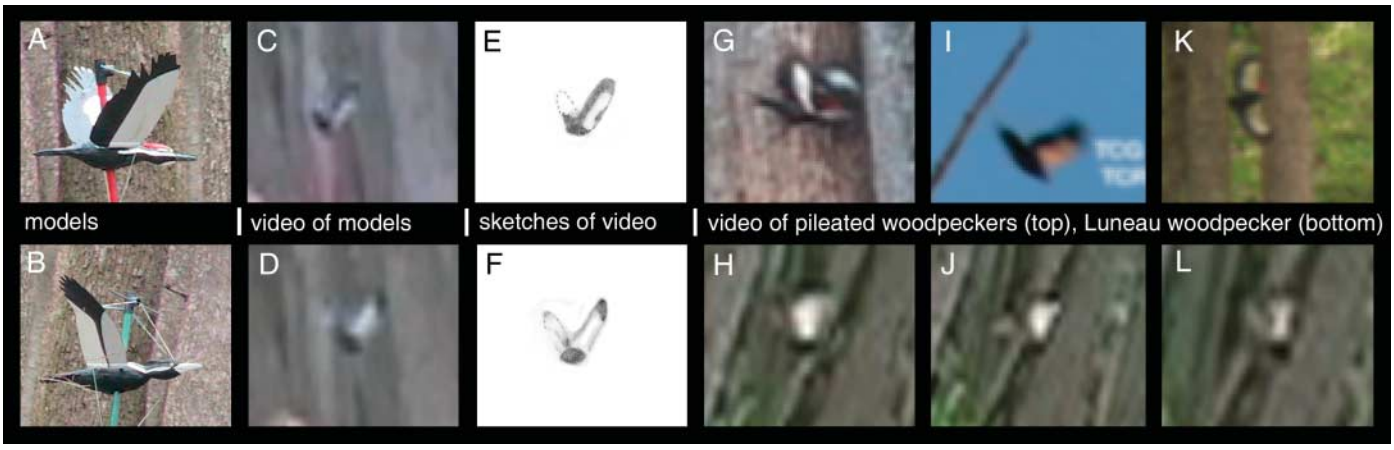

Fig. 2. Effects of video artifacts on wing patterns of pileated woodpecker and ivory-billed woodpecker. To reenact the Luneau video (*1*), life-sized models with flappable wings were painted to resemble pileated woodpeckers (**A**) and ivory-billed woodpeckers (**B**). Deinterlaced video fields of these models shot with the same camera, distance, and light conditions as the Luneau video reveal the prominent black edge on the pileated woodpecker model (**C**). The ivory-billed woodpecker model shows a white underwing with black wingtips, the central black wing line being lost because of white dominance and poor video resolution (**D**). Our interpretive sketches of these fields differentiate the clear black trailing edge of the pileated woodpecker (**E**) from indistinct dark borders of the ivory-billed woodpecker model (**F**), which are video artifacts. Sibley *et al*. (*2*) erroneously interpreted such artifacts in the Luneau video as a thin, black trailing edge. Deinterlaced, poor-resolution video fields of pileated woodpeckers in flight (**G**, **I**, and **K**) show wing patterns resembling the pileated woodpecker in the reenactment. Deinterlaced video fields from the Luneau video (**H**, **J**, and **L**) show wing patterns resembling the ivory-billed woodpecker in the reenactment.

material (SOM) text]. (ii) Proposed wing and tail movements during the woodpecker's launch do not match the video images. (iii) Sketched renditions of video fields incorporate video artifacts as plumage pattern and are unsupported by experimental or field documentation. (iv) It dismisses experimental demonstration that the observed underwing pattern matches a flapping model of an ivory-billed, not a pileated. (v) It invokes an extraordinary model of flapping flight whereby a bird in caudal view conceals dorsal wing surfaces on both downstroke and upstroke. (vi) Without supporting evidence, it dismisses additional features of the Luneau video that are consistent with ivory-billed and inconsistent with pileated.

White wing patch at launch. Contrary to (*2*), the pattern of white in field 33.3 matches an ivory-billed woodpecker wing viewed laterally from slightly below the horizontal (Fig. 1). Its size is fully consistent with an ivory-billed woodpecker (*3*) (SOM text).

The pattern in fields 16.7, 33.3, and 50 does not match a pileated woodpecker wing (Fig. 1). Sketches in (*2*) show a black rim around the edge of the white, but no such black appears in the actual video fields (grayish background areas are not associated with the wings). If the white were a pileated underwing, then unambiguous black should be present distally on all remiges viewed ventrally from any angle (Fig. 1) (*3*).

The statement that when woodpeckers launch "the initial wing extension happens very quickly and, given the angle at which the bird is viewed, the underwing should be visible" (*2*) is inconsistent with video evidence. Woodpecker launches are variable (*3*) but typically begin with the wings opening slightly as the body begins to pivot (SOM text). Sketches (*2*) of a bird suddenly airborne with wings outstretched overhead, body already lateral to the camera, yet tail and body still nearly vertical, are atypical. Even the videos that Sibley *et al*. cite (*5*) demonstrate our point.

Wings largely white, wingtips black. The crucial claim that during flight "the white on the wings can be accounted for by the ventral surface" (*2*) is incorrect, and the "wing-twisting" hypothesis contradicts all models and photographic analyses of flapping flight in birds (*6*–*8*). Again, when viewed in full, even the images and videos (*5*) Sibley *et al*. cite reveal dorsal wing surfaces visible caudally.

Ventral wing surfaces of a flying woodpecker viewed caudally are sometimes visible during mid-downstroke, but on the upstroke and immediately before the downstroke the dorsal surface prevails (*6*–*8*). Referring to the distinctive Luneau video, Sibley *et al*. (*2*) state that "lack of an obvious black trailing edge in most video frames does not rule out an identification of pileated woodpecker," but no video evidence exists to support this claim. To the contrary, the black portion of the ventral wing surface (>50% of the wing) (SOM) is visible in virtually every frame of a flying pileated woodpecker (Fig. 2) (*3*). The claim by Sibley *et al*. (*2*) that in certain fields the black wingtips of the woodpecker show a curved shape suggestive of pileated fails to acknowledge that movement blur is most pronounced at the wingtips and that in other fields of the Luneau video the shape is more suggestive of ivory-billed.

In the Luneau video, white dominates the wings throughout, including many unambiguously dorsal views (SOM). The left wing is white to its base as it emerges from behind the tree [field 250 and subsequent fields (*3*)] and in additional fields that show dorsal views during the latter stages of upstrokes (e.g., fields 700, 816.7, and 950). The right wing shows dorsal white as the bird veers left. Contrary to Sibley *et al*. (*2*), white is evident in many fields in which the wings are closing or folded during the upstroke (*3*), whereas similar positions in pileated woodpecker videos show all-dark wings. Extensive white along the rear dorsal surface, conspicuous black wingtips on every wingbeat, and absence of black along the rear edge of the wing eliminate pileated and represent the diagnostic wing pattern of an ivory-billed woodpecker.

We conducted experimental reenactments using ivory-billed and pileated models designed to demonstrate the full wing extension at the beginning of the downstroke and videoed these at shutter speeds slow enough to simulate conditions of the Luneau video (Fig. 2) (*3*). The ivory-billed model yielded images strikingly similar to those in the Luneau video, but comparable images of a pileated model revealed the expected black trailing edge and were incompatible with the Luneau video.

White on dorsum. We regard the presence of white on the back of the Luneau woodpecker as obvious and indisputable (SOM text). The statement that "little of its back is visible" (*2*) is irrelevant, because some white on an ivory-billed's back would be visible at virtually any caudal angle. The amount and placement of white is inconsistent with its being on the head and neck, which pointed directly away from view throughout. Reflection off a pileated's sooty-black back on a cloudy day cannot produce the persistent whitish areas visible at several angles. Finally, although resolution is too poor to identify a double stripe unambiguously, the suggestion of such exists in field 866.7.

Rapid and direct flight. The Luneau woodpecker flies with a wingbeat frequency of 8.6 Hz

without undulation for more than 4 s. The 1935 audio recording of a pair of ivory-billed woodpeckers at a nest (SOM text) captured one bird flying away with noisy wingbeats [as described in (*9*)] having a frequency of 8.4 Hz (*3*). The close match between the Luneau woodpecker and the 1935 recording is especially important because both are faster than any wingbeat frequency ever documented for pileated woodpecker. The sustained duration of this direct flight pattern by the Luneau woodpecker is extraordinary, because pileated woodpeckers typically shift to slower, deeper wingbeats moments after launching from a perch, even when the initial few beats are rapid (*3*).

Perched woodpecker. Contrary to the interpretation of Sibley *et al*. (*2*), the black and white object apparent in the Luneau video 26 s before the bird flies is consistent in size (35 to 45 cm), shape (vertically elongate, leaning away from the trunk), and pattern (black with white central patch) with a perched ivory-billed woodpecker [video close-up in (*3*)]. The object remains fixed on the trunk as the camera's viewing angle shifts relative positions of objects at different distances from the camera (fig. S2). Unlike the objects identified in figure S1 of Sibley *et al*. (*2*), this object is too large, too well-defined over a 6-s period, and its midportion too white to be a video artifact or leaf cluster. Moreover, the object was gone when the Luneau canoe came around the bend in the bayou and the woodpecker launched into flight nearby (fig. S2). It was never present on subsequent examinations of the site. Identity of this object is not crucial to identification of the flying bird, but we cannot explain its size, pattern, and disappearance from view except as an ivory-billed woodpecker that flew 3 m to hide behind a tupelo, then fled moments later as the canoe approached. No evaluation of the Luneau video can be considered exhaustive without a credible interpretation of this feature.

Interpretations of frames in the Luneau video by Sibley *et al*. (*2*) portray wing patterns, video artifacts, and wing twisting that accord neither with experimental and comparative findings nor with models of bird flight. Video (*1*), sightings (*10*, *11*), and suggestive acoustic evidence (*12*) establish that at least one ivory-billed woodpecker persisted in eastern Arkansas during 2004 and 2005, compelling vigorous search and conservation efforts in the Big Woods and elsewhere across the southeastern United States.

References and Notes

1. J. W. Fitzpatrick *et al.*, *Science* **308**, 1460 (2005).
2. D. A. Sibley, L. R. Bevier, M. A. Patten, C. S. Elphick, *Science* **311**, 1555 (2006); www.sciencemag.org/cgi/content/full/311/5767/1555a.
3. Our complete analysis of the Luneau video is presented in www.birds.cornell.edu/ivory/rediscovery/support.
4. D. A. Sibley, *The Sibley Guide to Birds* (Knopf, New York, 2000).
5. Referenced video clips at www.manybirds.com show an atypical, hovering launch by pileated woodpeckers and foraging hops, not flight initiation, of pale-billed woodpeckers (*Campephilus guatemalensis*). We call attention to the clip of lineated woodpeckers (*Dryocopus lineatus*) at this site, which demonstrates exactly our point about how woodpeckers typically launch.
6. U. M. Norberg, *Vertebrate Flight: Mechanics, Physiology, Morphology, Ecology and Evolution* (Springer-Verlag, New York, 1990).
7. J. M. V. Raynard, *Curr. Orn.* **5**, 1 (1988).
8. B. W. Tobalske, K. P. Dial, *J. Exp. Biol.* **199**, 263 (1996).
9. J. T. Tanner, *The Ivory-billed Woodpecker* (National Audubon Soc., New York, 1942).
10. K. V. Rosenberg, R. W. Rohrbaugh, M. Lammertink, *N. Am. Birds* **59**, 198 (2005).
11. Sibley *et al*. (*2*) incorrectly claim that the sight records we reported (*1*, *10*) "were all very brief and most involved a single observer, matching the pattern of reported observations over the past few decades." In no case since the 1940s was a report of an ivory-billed woodpecker (such as the original one by Gene Sparling) promptly followed by multiple repeat sightings in the same area—sightings that included a close encounter shared by two individuals, each having extensive experience with pileated woodpeckers in southern forests. After studying the evidence at length, the Bird Records Committee of the Arkansas Audubon Society voted unanimously to accept the documentation of ivory-billed woodpecker (www.arbirds.org/ivory_billed_woodpecker.html). Comparable validation by critical and experienced local experts has not occurred following any previous report of this species.
12. R. A. Charif *et al.*, *Science* **309**, 1489 (2005).

13. We are grateful to the following individuals for critical discussions about the video, woodpecker identification and behavior, bird flight dynamics, and video analysis of bird behavior: L. Bevier, K. Bostwick, E. Brinkley, M. Braun, B. Clock, M. Dantzker, K. Dial, J. Hailman, J. Jackson, D. James, D. Lane, C. Marantz, K. McGowan, M. Patten, R. Prum, M. Robbins, G. Rosenberg, D. Sibley, J. Sterling, D. Stotz, B. Sullivan, B. Tobalske, J. Wells, B. Whitney, E. Weiner, D. Willard, H. Winkler, and K. Zimmer. We especially thank J. V. Remsen Jr. for critical analysis of evidence and assistance with the manuscript. We thank the curators and collection managers of the following collections for access to specimens under their care: American Museum of Natural History, Cornell Museum of Vertebrates, Field Museum of Natural History, Louisiana State University Museum of Natural Science, Museum of Comparative Zoology at Harvard University, Peabody Museum at Yale University, Museo de Historia Natural de Cuba, Instituto de Ecología y Sistematica (La Habana), and Universidad de La Habana.

Supporting Online Material

www.sciencemag.org/cgi/content/full/311/5767/1555b/DC1
SOM Text
Figs. S1 to S3
References and Notes

13 January 2006; accepted 9 March 2006
10.1126/science.1123581

ERRATUM

Post date 9 June 2006

Technical Comments: "Response to Comment on 'Ivory-billed woodpecker (*Campephilus principalis*) persists in continental North America'" by J. W. Fitzpatrick *et al.* (17 Mar. 2005, http://www.sciencemag.org/cgi/content/full/311/5767/1555b). In reference (*11*), it is stated that "After studying the evidence at length, the Bird Records Committee of the Arkansas Audubon Society voted unanimously to accept the documentation of ivory-billed woodpecker (www.arbirds.org/ivory_billed_woodpecker.html)." This is incorrect; the Committee did accept the documentation, but the vote was not unanimous.

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Science **311** (5767), 1555.
DOI: 10.1126/science.1123581