Bigfoot's Screen Test

Recent analyses propose that the 1967 film of "Bigfoot" documents a large, feral nonhuman primate unknown to modern science. Known sources of measurement error and existing data on human locomotion suggest a more cautious conclusion.

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O f the varied sources of evidence invoked to support the existence of Bigfoot, none is more widely cited than the 1967 film of a large, hairy bipedal figure walking along the Bluff Creek drainage in northern California. Known as the Patterson-Gimlin film, this short motion picture (less than one minute running time) has generated considerable controversy with respect to its authenticity. The film depicts a burly figure walking deliberately away from the cameraman. The footage is often blurry due to excessive camera movement. In the most famous frame, the film subject turns its head and shoulders toward the camera to peer at its pursuer. Details of the subject's physiognomy cannot be discerned.

Recently, three independent studies have presented arguments suggesting that fabrication of the film would have been unlikely or impossible given the technology of the day. The implication, therefore, is that giant, bipedal primates have inhabited wilderness areas of the Pacific Northwest in recent times, yet have remained undiscovered by wildlife biologists and unrecognized among the mainstream scientific community.

In separate studies, Chris Murphy of Progressive Research[1] and Jeff Glickman of Photek and the North American Science Institute (NASI),[2] achieved a remarkable convergence of results when both investigators concluded, via different methods of estimation, that the film subject stood fully 7'3 1/2" (222 cm) tall. Glickman's study (1998) also concluded that the chest of the figure measured a hefty 83" in circumference and that the film subject weighed in at 1,957 pounds.

In his book *Big Footprints* (1992), Grover Krantz makes two claims with respect to the film. First, Krantz argues that no human exists whose body dimensions match those of the film subject, even given the effects of a

Drawing by Jake Page

furry costume. Second, he claims that the kinematics of the film subject are decidedly nonhuman, that the gait could not be duplicated by a person wearing a costume.

In essence, two claims seriously undermine the hypothesis that the Patterson-Gimlin film is a hoax: (1) that the film subject's body dimensions are outside the range of human variation, and (2) that the gait of the film subject cannot be duplicated by a person.

In this report, we argue that the exact dimensions of the film subject are unknowable and that the gait of the film subject is easily reproducible by human beings of average stature. Neither of these arguments demonstrate that the subject of the

film is not a Bigfoot; we simply wish to point out that recent trumpetings in cyberspace about the film's authenticity may not enjoy a solid empirical foundation.[3]

Analyzing the Claims

It is alleged that the film subject left tracks on the Bluff Creek sandbar, which were cast subsequent to filming. The tracks measured 14 1/2" in length. About ten days after the film was made, Bigfoot investigator Bob Titmus reconstructed the subject's course of travel during filming and attempted to establish

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the position of Roger Patterson's camera during the event. These reconstructions were performed without a measuring tape or camera[4]; quantitative efforts to map the positions of the cameraman and film the subject were made in subsequent years.[5] Thus, we know the general course of travel of the film subject but not its exact traverse (cf. Byrne 1975, Green 1981).

Murphy assesses the subject's height by taking a known quantity—subject heel width from footprint casts—and using this scalar as a calibration standard to determine film subject dimensions. Given the heel calibration and a "stoop factor" correction, he arrives at the stature of 7'3 1/2". Murphy suggests that a stick recovered from the film site years after the event is also an appropriate calibration standard because the subject ostensibly is seen stepping over this stick during the film. Using this independent criterion, he obtains the same result.

In the NASI report, Glickman employs a third method that also yields the same height for the film subject. His method involves using a later photograph from the film site of an individual of known height, purportedly standing along the original path of the film subject, as a basis from which to determine the film subject's dimensions. This calibration photograph was taken by long-time Bigfoot investigator Peter Byrne five years after the film was made, and Glickman uses the alignment of dead trees that appear in the background of the film to match the photo with the relevant film frames.

Murphy and Glickman recognize that for a calibration standard to be valid, the object used for calibration must be coplanar with the film subject,[6] such that the calibration object and subject are equidistant from the optical axis of the camera.

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It is also well-established that, in order to minimize error, a calibration standard must be sufficiently large relative to the object being measured. Given the uncertainty of subject position in the film, it is not clear that objects chosen for calibration purposes lie completely within the intended reference plane. The dimension to be used in calibration and the subject of interest must be positioned equidistant to the camera lens to provide accurate measurement. Thus, a scalar dimension (a known quantity with which to scale other dimensions on an object or image) measured from a calibration standard that is not exactly coincident with a reference plane, even if that standard occupies a point in that plane, will yield uncorrectable errors if this obliquity is present (i.e., the standard is not aligned with the reference plane) but its degree is not known.

For the same reason, measurement error can occur if scalar dimensions and the subject occupy a desired reference plane but when the camera's optical axis is not positioned perpendicular to that plane. This problem becomes particularly acute in the context of the Patterson-Gimlin film because camera position was not controlled relative to the subject's movements along a path defining the reference plane; thus, "coplanar" standard and subject may not be equidistant to the camera lens. Objects that are actually not coplanar may appear to be so if the camera lens is obliquely set relative to the true plane of reference.

Testing Measurement Error

To illustrate the problems posed by these sources of error, we estimated a human subject's stature from videotape recordings using calibration objects of known dimension as scalars under ideal laboratory conditions. One of us (Daegling) was filmed at a distance of 490 cm from the camera (Figure 1). Three sources of calibration were used: a two-meter standard, Daegling's foot length, and his heel width. These standards were digitized on the image[7] and used to estimate Daegling's true height (194.5 cm). As expected, the two-meter standard yielded a very good estimate of stature (193.6 cm). Repeated measures within observers indicated that digitizing error was negligible, and the between-observer standard deviation was a respectable 0.44 cm. Using Daegling's foot length as a standard, the error increases markedly (204.3 cm or 3 percent above the true value). Using a heel-width calibration standard the error balloons to 28 percent (249.4 cm, with pronounced inter-observer error [sd=6.5]). These figures make no allowance for camera obliquity or objects off the intended reference plane. If either of these factors are introduced, errors will increase. For example, when foot length is offset from the reference plane by 10 degrees but the length of the foot is considered to be the same as before, stature estimates are off by about 10 percent (214.9 cm). At a 20-degree offset, the overestimate is about 17 percent (227.7 cm). The degree to which the foot is out of plane cannot be reliably assessed from an image unless an independent scalar exists *in the plane of reference.* Ostensibly Murphy has another scalar in the stick
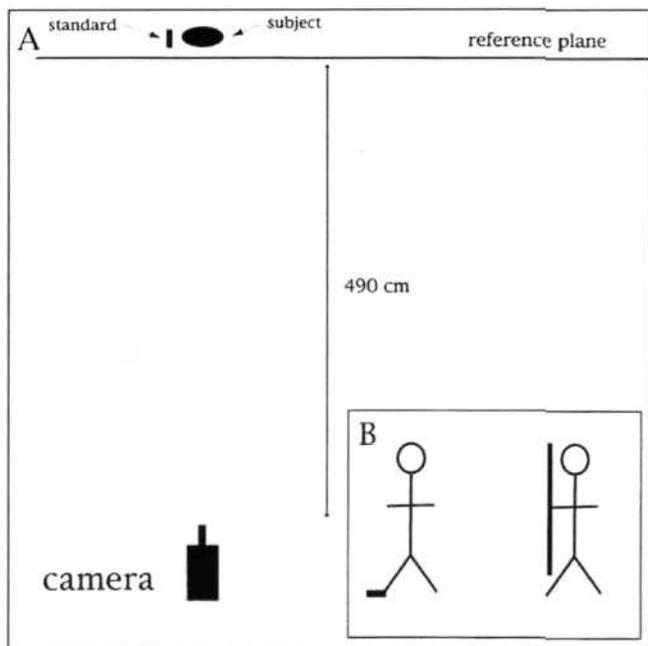

Figure 1. A. Bird's-eye view of ideal conditions for quantitative analysis. Both calibration standard and subject of interest occupy a reference plane that is situated perpendicular to the optical axis of the lens. A scalar similar in size to the subject and that occupies the greatest amount of viewing volume is preferred. Smaller scalars yield larger errors.

Figure 1. B. The accurate estimation of a dimension (stature in this case) is dependent on the error with which a calibration standard can be measured. A 1 cm error in digitizing a standard may be tolerable in a yardstick (right), but will yield poor estimates of stature if made on a smaller object (a foot, left).
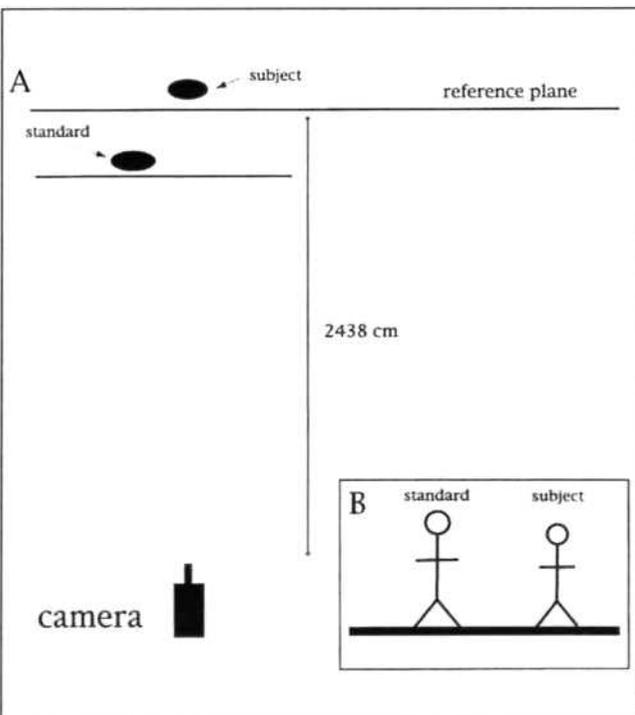

Figure 2. A. When calibration standard and subject do not occupy the same reference plane, errors in estimating subject parameters are inevitable.

Figure 2. B. Is the standard bigger than the subject or simply out of plane? Even if the out-of-plane position of the standard can be detected, the degree to which it is removed from the reference plane cannot be evaluated from the image.

over which the film subject steps early in the film. Not only is this calibration object relatively small, but there is also no way to verify that the long axis of the stick (the intended scalar dimension) is perpendicular to the camera lens. These observations suggest that the magnitude of error introduced in Murphy's method is unknown, is probably unacceptably large, and cannot be corrected given the known parameters of the film.

Glickman's method is far superior since the calibration standard is relatively large.[8] It is asserted that the film subject's course of travel in Figure 6 of the NASI report and the standard included in the figure (an individual at the film site) occupy the intended reference plane. The report does not specify how the coincidence of film subject and standard in this plane is verified. The calibration standard was scaled by superimposing dead trees from the background of the 1972 photograph onto the 1967 film. There may be errors associated with this superimposition, but their magnitude is not known. In any case, this alignment, however precise, does not establish that the standard and the film subject are coplanar. The likelihood exists that there are out-of-plane errors in Glickman's calculations.

Again under ideal laboratory conditions, a subject (179 cm tall) and a calibration standard (Daegling's standing height) were filmed with the lens perpendicular to the reference plane 80 feet (2,438 cm) away (Figure 2), a distance comparable to estimates of the distance of the film subject from the camera at the onset of what is regarded as the best sequence of footage.
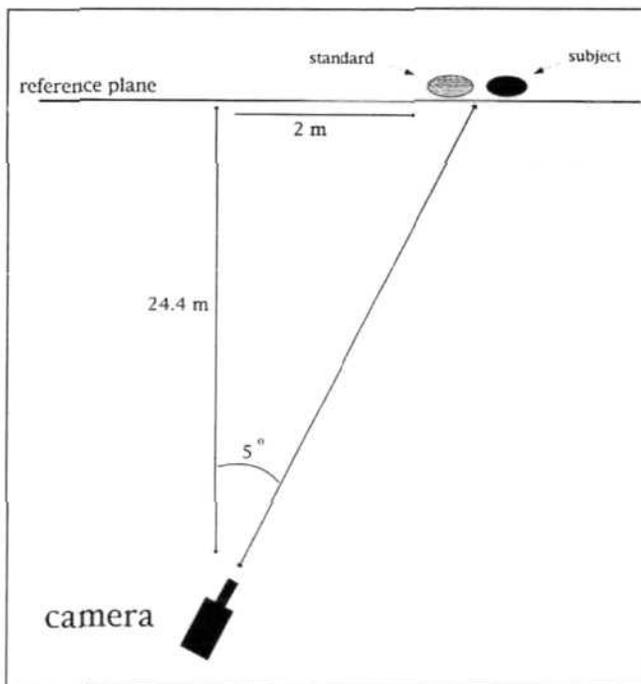

Figure 3. If the optical axis of the camera is not perpendicular to the intended reference plane, the calibration standard will not correctly estimate subject dimensions. This may also have the illusory effect of making out-of-plane objects appear coplanar (i.e., equidistant from the camera). In the example shown here, standard and subject are 60 cm apart but the standard underestimates subject stature by over 8 percent. The camera rotation requires definition of a new reference plane and repositioning of the standard for accurate estimation of subject parameters. Figure is not to scale.

Table 1. Striding and Compliant gaits

Subject	Gait type	speed (m/sec)	stride length (cm)
Daegling	striding	2.1 (0.18)	216 (7.6)
	compliant	3.1 (0.15)	293 (10.7)
Schmitt	striding	2.2 (0.34)	208 (15.9)
	compliant	3.0 (0.08)	288 (6.5)
Subject #3	striding	2.5 (0.59)	224 (53.2)
	compliant	3.8 (0.31)	338 (22.8)
Subject#4	striding	2.2 (0.14)	201 (13.1)
	compliant	2.9 (0.10)	269 (9.7)
film subject	compliant	16 fps 1.9	237–310
		18 fps 2.1	
		24 fps 2.8	

Means and standard deviations are given for N=4 (Daegling & Schmitt), N=6 (subject #3) and N=10 (subject #4) trials. Statures are 194.5 cm (Daegling), 188 cm (Schmitt), 176 cm (subject #3, an adult male), 183 cm (subject #4, another adult male), and 222 cm (film subject, Glickman's estimate). Speeds and stride lengths are calculated from forced, high-speed walks in human subjects. Stride for the film subject is given as a range of estimates (Perez 1992; Glickman 1998). Film speed is not known, so three estimates for subject velocity are given for different film speeds (D.W. Grieve, reprinted in Byrne 1975). Claims that the film subject walks too fast for a human are countered by the observation that compliant gaits can increase walking speed to match or exceed that of the film subject.

When positioned in the reference plane with the subject, the standard (Daegling) provides an excellent estimate of subject height (178.4 cm, an error below 1 percent). When the standard is out of plane by only 1 m (closer to lens) the subject's apparent height is 172.3 cm, nearly 4 percent less than the true stature. As the standard moves even closer to the camera and increasingly out of plane, the error is exacerbated; true stature is underestimated by nearly 15 percent (152.4 cm) at a position 4 m out of plane.[9]

These errors assume that the lens is positioned perpendicular to the reference plane, to satisfy the need for calibration object and subject to be positioned equidistant from the optical axis of the camera lens. The various sketches reconstructing camera and subject position in the Patterson-Gimlin film, however, suggest that the camera was only intermittently, if ever, fully perpendicular to the reference plane.[10] This would result in dissimilar distances of calibration object and film subject from the camera lens, with attendant errors in stature estimation. How serious is this problem? When we rotated the camera 5 degrees off an intended reference plane (Figure 3), a calibration standard of 176 cm failed to predict Schmitt's stature of 188 cm with acceptable accuracy, even though scalar and subject were "coplanar." The apparent stature was 172 cm, fully 8 percent smaller than true stature.[11]

Glickman suggests that the error of his estimate of the film subject may be on the order of one inch (< 3 cm) although no error analysis is provided to verify this. If this error magnitude is to be accepted, the following conditions must have been

met: (1) the lens was positioned perpendicular to the reference plane in which measurements were made, (2) the subject and calibration object were both positioned in the plane of reference such that they are equidistant from the optical axis of the lens, and (3) the scalar dimension measured on the calibration object was precisely in line with the reference plane (i.e., not off-angle relative the camera lens). Published material to date does not demonstrate that these conditions apply.

Glickman's estimates of other subject parameters derived from linear measurements (specifically, chest circumference and body weight) will have errors compounded in the process of calculation. He bases his estimate of chest circumference on a formula for an ellipse that uses linear estimates of chest depth

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and width as minor and major axes. To reconstruct these axes, Glickman attempts to correct for out-of-plane rotation of the subject's chest. Given the uncertainty of subject position, camera position, and the lack of an accurate independent scalar in the film, it is virtually inconceivable that a mathematical correction would yield a true estimate (see Miller and Petak 1973; Noss 1967; Schmitt 1994; Chan 1997). Glickman uses an allometric equation based on living primates to calculate a body mass for the film subject of 1,957 lbs.—absurdly large unless one wishes to posit that Bigfoot is constructed of nonstandard biological tissues.[12]

Krantz's estimate of the film subject's stature is 6'6" (198 cm), well within human limits, but he argues that the chest width of the subject is incompatible with the human form: "I can confidently state that no man of that stature is built that broadly."[13] Assuming that these parameters are measured without error, this assertion may be refuted by a quick consultation of the *Anthropometric Source Book* (1978). Chest width is measured by Krantz in the same fashion as a distance known as "interscye" in the anthropometric literature. In a sample of 1,004 men of the German Air Force, interscye of the ninety-fifth percentile is 49.6 cm, a good 3 cm larger than Bigfoot's impossibly wide thorax. The ninety-fifth percentile stature is 187.1 cm in this group, less than 4 inches shorter than the film subject. Unless Krantz would argue that taller Air Force personnel necessarily have narrower chests, his confident statement is admirable for its faith but not its veracity.

Nonhuman Locomotion?

Bigfoot proponents have suggested that the high-velocity, flexed-hip, flexed-knee gait of the subject, which also walks with its trunk pitched slightly forward, is absolutely nontypical of human locomotion. Krantz again opines, "[J]udging from the way it walks, there is no possibility that the film sub-

ject can be a man in a fur suit."[14] Repeated viewings of the film suggest that, indeed, the subject does not exhibit the normal striding gait of human bipedalism. But humans are capable of locomotion that involves deeper flexion of the knees and hips similar to that seen in the film subject, and this type of locomotion (a "compliant gait," Alexander 1992) has been studied under controlled conditions (Yaguramaki et al. 1995; Li et al. 1996; Schmitt et al. 1996; Cook et al. 1997). Two features of the subject's gait that Krantz asserts are atypical of humans are in fact observable in humans who utilize a compliant gait: (1) reduction of vertical oscillations of the head and trunk typical of striding bipedalism, and (2) an extended period of support (weight-bearing) phase during a locomotor cycle (McMahon et al. 1987; Alexander 1992; Schmitt et al. 1996). Bigfoot investigators have also remarked upon the apparent high speed of the film subject's gait and the length of its stride as being beyond human capability.[15] When a compliant gait is employed, however, there are two measurable effects: It is possible to walk faster, and the stride length is increased (Table 1). Glickman's calculated stride length for the film subject is 237 cm. This figure is easily surpassed by the authors and two other measured subjects, all of whom are less than 200 cm tall. Reported stride lengths based on footprints at the film site range from 284 cm to 310 cm (Perez 1992). A human over 200 cm tall could be expected to match or exceed these higher figures using a compliant gait.

Another peculiarity of the film subject is the forward pitch of the trunk during locomotion. This is again atypical of striding bipedalism, but when humans do adopt this strange posture, a compliant gait becomes the obligate form of bipedalism (Yaguramaki et al. 1995). Assertions that the kinematics of the film subject cannot be duplicated by human agents are thus demonstrably false.

There remains the remarkable coincidence that independent studies have yielded identical results for stature of the film subject. Does this not "validate" the results in the tradition of rigorous science? Perhaps it would if Murphy's study did not involve a fudge factor in the form of a "stoop correction" that can be arbitrarily applied to the stature estimate.[16] This observation, in addition to the enormous potential for calibration errors in Murphy's study, suggests that the convergent results are most charitably regarded as a happy coincidence.

Conclusion

Bigfoot proponents have long decried the undeniable fact that detailed scientific investigation of the Patterson-Gimlin film has been lacking. There are, however, intractable difficulties involved in obtaining reliable data from image analysis where conditions are far from ideal. The potential for calibration errors in analyses of the Patterson-Gimlin film has undermined attempts to extract quantitative data from it.

Uncertainties in subject and camera positions doom quan-

titative analysis of this centerpiece of Bigfoot lore, as do the additional problems posed by poor image quality and artifacts of subject and camera movement. Just as measurement of film parameters and qualitative assessment of kinematics cannot demonstrate that the film subject is nonhuman, there are probably no means by which to demonstrate conclusively that the film subject represents a human agent either. Based on our analysis of gait and problems inherent in estimating subject dimensions, it is our opinion that it is not possible to evaluate the identity of the film subject with any confidence. Consequently, the Patterson-Gimlin film does not provide unequivocal proof of Bigfoot's existence, nor can the film be used to substantiate other putative images of Bigfoot (e.g. the Redwoods "playmate" video).

Acknowledgments

Notes

1. Progressive Research is a British Columbia-based organization investigating Bigfoot evidence and marketing Bigfoot merchandise. Murphy's research results are posted on the Internet Virtual Bigfoot Conference (IVBC) established by Henry Franzoni. Readers may access the conference at www.teleport.com/~caveman/ivbc.html. These results are also summarized in *NASI News* (Vol. I).

2. Glickman is a certified forensic examiner who specializes in image enhancement and reconstruction. He has served as the executive director of the North American Science Institute (NASI), an organization dedicated to getting to the bottom of the Bigfoot phenomenon. His research results appear in "Toward a Resolution of the Bigfoot Phenomenon," a 1998 publication of the institute.

3. Chris Murphy's IVBC posting of June 9, 1997, states, "With the current findings, there is little room for doubt on the reality of the creature in the Patterson-Gimlin film. In other words, it was NOT a hoax." Similarly incautious conclusions can be found peppered throughout the various Web sites dealing with Bigfoot.

4. Rene Dahinden, personal communication, July 15, 1998. Dahinden has been involved in Bigfoot research for over forty years, and has been investigating the circumstances of the Patterson film since it was made in 1967.

5. John Green mapped the site in June 1968, Rene Dahinden did so in 1971, and Peter Byrne undertook the task in 1972. Grover Krantz used Titmus's schematic and his own analysis of the film to produce a revised diagram. The various schematics are in general agreement but differ in details of the exact path of the film subject and its relation to the camera.

6. Of course, subject and object may always be said to be coplanar, except that registration of two points does not define a *unique* plane. To establish that objects are coplanar requires registration of at least three points, or a line and a point. In the case of the Patterson film, the desired reference plane corresponds to the vertical extension of the "line" of travel of the film subject.

7. Images were digitized using Peak Performance software, Motus 4.0. Englewood, Colorado. To eliminate any of our own bias in assessing calibration errors, we used a "blind" measurement protocol. Five individuals, who were not informed of study objectives were asked to measure calibration standards. Each individual was then asked to measure subject stature for each test in a randomized design (e.g., individual 1 would measure stature based on individual 3's calibration, and no individual had knowledge of true values of calibration standards or subjects). Values reported in the text represent the mean value over five observations.

8. While the calibration object is of preferred size, the fact that both subject and this object are small relative to the viewing volume is less than ideal for quantitative analysis.

9. Subject height will be similarly overestimated if the standard is positioned behind the subject. Ironically, as the distance of subject and standard from the lens increases, the errors will be smaller for a given distance that they are off-plane, but they will still exist. At ever-increasing distances, however, image quality may deteriorate. This may be especially true in cases where objects are small within a film frame, as occurs throughout the Patterson-Gimlin film.

10. Schematic drawings by Krantz, Titmus, Dahinden, and Green are reproduced in *Bigfoot at Bluff Creek* by Danny Perez, 1992, Center for Bigfoot Studies, Norwalk, California.

11. With respect to conditions of the Patterson-Gimlin film, the magnitude of this source of error depends on the interactive effects of (1) the degree of obliquity of the lens' optical axis relative to the intended reference plane, (2) the distance of subject and standard from each other, and (3) the distance of each from the camera lens.

12. Assuming the film subject has a density similar to water (reasonable for most animals), one can model the subject as a water-filled cylinder and mathematically "weigh" it, with no allowance for tapering of the head or lower limbs. This procedure produces a very rough high-end estimate of mass. Assuming Glickman's estimates are accurate, this cylinder weighs 1,625 lbs., well below the 1,957 lb. figure given in the NASI report. The nearly one-ton Bigfoot weighs nearly five times more than a large male gorilla and outweighs the heaviest polar bears by over 200kg (McDonald 1984).

13. Page 118, *Big Footprints*. It is unclear whether "that stature" to which Krantz refers is his own or the film subject's. For the subsequent argument, it scarcely matters.

14. Page 115, *Big Footprints*.

15. Rene Dahinden (personal communication and Perez 1992) reports that, on one of his numerous visits to the film site, he and others present were incapable of walking the distance traveled by the film subject in the time that it did so (assuming a film speed of 24 fps).

16. Calculation of a "stoop correction" is unnecessary in any case: one can measure body segments regardless of their orientation to one another and sum these to arrive at stature.

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