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## Demographic, residential, and socioeconomic effects on the distribution of 19th century African-American stature

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# Demographic, Residential, and Socioeconomic Effects on the Distribution of 19<sup>th</sup> Century African-American Stature

SCOTT ALAN CARSON

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# Demographic, Residential, and Socioeconomic Effects on the Distribution of 19<sup>th</sup> Century African-American Stature

## Abstract

The use of height data to measure living standards is now a well-established method in the economic literature, and heights are related with vitamin D. Although African-Americans and whites have the genetic ability to reach similar terminal statures, 19<sup>th</sup> century blacks were consistently shorter than whites. Greater insolation (vitamin D production), is documented here to be associated with taller black statures. Consistent with the insolation-hypothesis, mulattos were taller than darker pigmented blacks, and most of the mulatto-black stature differential was attributable to age and insolation. Black farmers were taller than workers in other occupations, and black statures increased during the antebellum period and decreased with slavery's elimination, which is observed across the stature distribution.

JEL Code: J16.

Keywords: 19th century African-American stature, insolation, quantile regression.

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## I. Introduction

The use of height data to measure living standards is now a well-established method in economics (Fogel, 1994, p. 138). A populations' average stature reflects the cumulative interaction between nutrition, disease exposure, work, and the physical environment (Steckel, 1979, pp. 365-367; Tanner, 1962, pp. 1-27). By considering average versus individual stature, genetic differences are mitigated, leaving only the influences of the economic and physical environments on stature. When diets, health, and physical environments improve, average stature increases, and decreases when diets become less nutritious, disease environments deteriorate, or the physical environment places more stress on the body. Therefore, stature provides considerable insights into understanding historical processes and augments other welfare measures for 19<sup>th</sup> century African-Americans. Using a source of 19<sup>th</sup> century United States prison records and robust statistics, the present study contrasts the heights of comparable blacks and mulattos in the 19<sup>th</sup> century US and proposes a new explanation for traditional sources of black stature differences by socioeconomic status. An additional explanation for the mulatto stature advantage is also considered.

An unexplored source for 19<sup>th</sup> century stature variation may be related to biology, especially its relation to geography. Calcium and vitamin D are two chemical elements required throughout life for healthy bone and teeth formation; however, their abundance are most critical during younger ages (Wardlaw, Hampl, and Divilestro, 2004, pp. 394-396; Tortolani et al, 2002, p. 60). Calcium generally comes from dairy products, and vitamin D is not dietary but is produced by the synthesis of cholesterol and sunlight in the

epidermis' stratum granulosum (Holick, 2004a, pp. 363-364; Nesby-O'dell, 2002, p. 187; Loomis, 1967, p. 501; Norman, 1998, p. 1108; Holick, 2007). Vitamin D is vital in all vertebrates because it allows them to absorb more calcium from their diets and contributes to stronger skeletal systems (Jablonski, 2006, p. 62).<sup>1</sup> Greater direct sunlight (insolation) produces more vitamin D, and vitamin D is related to adult terminal stature (Xiong et al, 2005, pp. 228, 230-231; X-ZLiu et al, 2003; Ginsburg et al 1998; Uitterlinden et al, 2004). In order of importance, the primary sources of vitamin D in humans are the amount of time exposed to sunlight, skin pigmentation, and nativity (Holick et al., 1981, p. 590).

Vitamin D production also depends on melanin in the stratum corneum (Norman, 1998, p. 1108), and lighter colored 19<sup>th</sup> century blacks were consistently taller than darker pigmented blacks (Tanner, 1962, pp. 150-151; Tanner, 1977; Steckel, 1979, pp. 374-376; Margo and Steckel, 1982, pp. 532-34, Table 6; Bodenhorn, 1999, 2001; Xiong et al, 2005, pp. 228, 231; Z Liu, 2003, p. 825). More melanin (skin pigmentation) in the stratum corneum interferes with vitamin D's synthesis in the stratum granulosum, and darker pigmentation filters between 50 to 95 percent of the sunlight that reaches the stratum granulosum (Jablonski, 2006, p. 80-81; Kaidbey et al., 1979, pp. 249 and 253; Loomis, 1967, p. 502; Weisberg et al, 2004, p. 1703S; Holick, 2007, p. 270).<sup>2</sup> Moreover, a common explanation for taller mulatto statures is that 19<sup>th</sup> century social and economic forces favored fairer complexions over lighter complexions, and lighter colored blacks benefited from these social and economic institutions (Margo and Steckel, 1982, p. 521;

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<sup>1</sup> There are few dietary sources of vitamin D.

<sup>2</sup> To address rickets in the US population, in the 1930s the federal government advocated fortification of the US milk supply with vitamin D (Holick, 2004, p. 1679S).

Bodenhorn, 1999, p. 983). Nonetheless, a more complete explanation that addresses the interaction between stature, sunlight, and vitamin D production may also explain part of the mulatto stature advantage. To firmly establish a connection between stature, insolation, and vitamin D, it is necessary to test the stature insolation hypothesis across different samples and across their stature distributions.

It is against this backdrop that this paper addresses two paths of inquiry into 19<sup>th</sup> century African-American stature variation. First, how were insolation and vitamin D production related to stature across the black stature distribution, and did darker colored blacks have larger stature returns than taller mulattos from the beneficial aspect of vitamin D production? If insolation explains a significant share of the mulatto-black stature gap, the traditional mulatto effect attributable to racial inequalities may overstate the role of social forces explaining the mulatto-black stature differential. This study finds that black statures were positively related with exposure to insolation across the stature distribution, and darker blacks had larger stature returns with insolation than lighter mulattos. Robust statistics and a stature decomposition illustrate that insolation and vitamin D production were significant in 19<sup>th</sup> century black and mulatto statures. Therefore, not all of the mulatto effect is attributable to social forces. Second, how did black and mulatto statures vary with respect to Southern institutional change? Southern black statures ironically increased during the final years of the antebellum period and temporarily declined with emancipation.

## II. Data

### *Prison Records*

The data used here to study black statures is part of a large 19<sup>th</sup> century prison sample. All state prison repositories were contacted and available records were acquired and entered into a master data set. These prison records include Arizona, California, Colorado, Idaho, Illinois, Kansas, Kentucky, Missouri, New Mexico, Ohio, Oregon, Pennsylvania, Texas, and Washington (Table 1). Most blacks in the sample were imprisoned in the Deep South or Border States—Kentucky, Missouri, Georgia and Texas. However, Northern and Western states are also represented in the sample. The sample composition indicates these prison records represent rural conditions among the black Southern population, and about 20 percent of the sample was classified as mulatto.

Table 1, African-Americans in Nineteenth Century US State Penitentiaries

<i>State</i>	<i>Black</i>	<i>Mulatto</i>	<i>Total</i>	<i>Percent Mulatto</i>
AZ	113	35	148	23.65
CA	321	112	433	25.87
CO	741	179	920	19.46
ID	90	14	104	13.46
IL	746	472	1,218	38.75
KS	788	188	976	19.26
KY	5,115	1,084	6,199	17.49
MO	7,587	2,889	10,476	27.58
NM	344	0	344	0
OH	4,384	893	5,277	16.92
OR	55	6	61	9.84
PA	2,697	1,131	3,828	29.55
TX	21,744	5,512	27,256	20.22
Total	44,725	12,517	57,240	21.85

Source: Data used to study black and white anthropometrics is a subset of a much larger 19<sup>th</sup> century prison sample. All available records from American state repositories have been acquired and entered into a master file. These records include Arizona, California, Colorado, Idaho, Illinois, Kansas, Kentucky, Missouri, New Mexico, Ohio, Oregon, Pennsylvania, Texas, Utah and Washington.

Notes: Stature is in centimeters. The occupation classification scheme is consistent with Ferrie (1997).

All historical height data have various biases, and prison and military records are the most common sources for historical stature data. In addition to black under representation, one common shortfall of military samples is a truncation bias imposed by minimum stature requirements (Fogel et al, 1978, p. 85; Sokoloff and Vilaflor, 1982, p. 457, Figure 1; A'Hearn, 2004). Fortunately, prison records do not implicitly suffer from



such a constraint and the subsequent truncation bias observed in military samples. However, prison records are not above scrutiny. The prison data may have selected many of the materially poorest individuals who were drawn from lower socioeconomic groups, that segment of society most vulnerable to economic change (Bogin, 1991, p. 288; Komlos and Baten, 2004, p. 199; Nicholas and Steckel, p. 944). For height as an indicator of biological variation, this kind of selection is preferable to that which marks many military records – minimum height requirements for service (Fogel, 1978, p. 85; Sokoloff and Vilaflor, 1982, p. 457, Figure 1). Moreover, at the margins of subsistence, prison records more clearly illustrate factors associated with stature variation. Because the purpose of this study is to compare 19<sup>th</sup> century male black statures, females and immigrants are excluded from the analysis.

There also is concern over entry requirements, and physical descriptions were recorded by prison enumerators at the time of incarceration as a means of identification and, therefore, reflect pre-incarceration conditions. Between 1830 and 1920, prison officials routinely recorded the dates inmates were received, age, complexion, nativity, stature, pre-incarceration occupation, and crime. All records with complete age, stature, occupation, and nativity were collected. There was great care recording inmate statures because accurate measurement had legal implications for identification in the event that inmates escaped and were later recaptured.<sup>3</sup> Arrests and prosecutions across states may result in various selection biases that affect the results of this analysis. However, black stature variation within US prisons are consistent with other stature studies (Steckel,

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<sup>3</sup> Many inmate statures were recorded at quarter, eighth, and even sixteenth increments.

1979; Margo and Steckel, 1982; Nicholas and Steckel, 1991, pp. 941-943; Komlos, 1992; Komlos and Coclanis, 1997; Bodenhorn, 1999; Sünder, 2004).

Fortunately, inmate enumerators were quite thorough when recording inmate complexion and occupation. For example, enumerators recorded inmates' race in a complexion category, and African-Americans were recorded as black, light-black, dark-black, and various shades of mulatto (Komlos and Coclanis, 1997). While mulatto inmates possessed genetic traits from both European and African ancestry, they were treated as blacks in the 19<sup>th</sup> century US and are compared here with blacks. Prison enumerators also recorded a broad continuum of occupations and defined them narrowly, recording over 200 different occupations, which are classified here into four categories: merchants and high skilled workers are classified as white-collar workers; light manufacturing, craft workers, and carpenters are classified as skilled workers; workers in the agricultural sector are classified as farmers; laborers and miners are classified as unskilled workers (Tanner, 1977, p. 346; Ladurie, 1979; Margo and Steckel, 1992; p. 520). Unfortunately, inmate enumerators did not distinguish between farm and common laborers. Since common laborers probably encountered less favorable biological conditions than farm laborers during childhood and adolescence, this potentially overestimates the biological benefits of being a common laborer and underestimates the advantages of being a farm laborer.

Table 2, Descriptive Statistics of African-Americans in National Prison Data

	<i>Blacks</i>		<i>Mulatto</i>			<i>Blacks</i>		<i>Mulatto</i>	
Ages	N	Percent	N	Percent	Occupations	N	Percent	N	Percent
Teens	8,268	18.49	2,425	19.38	White-Collar	1,50	3.36	832	6.65
20s	24,134	53.96	6,872	54.91	Skilled	4,485	10.03	1,740	13.90
30s	7,835	17.52	2,170	17.34	Farmers	4,593	10.27	1,248	9.97
40s	2,988	6.68	722	5.77	Unskilled	33,244	74.33	8,353	66.74
50s	1,050	2.35	244	1.95	No	902	2.02	342	2.73
					Occupations				
60s	370	.83	72	.58	Nativity				
70s	80	.18	10	.08	Northeast	175	.39	64	.51
Birth					Middle	2,810	6.28	1,218	9.73
Decade					Atlantic				
1800s	137	.31	54	.43	Great Lakes	2,565	5.74	932	7.45
1810s	427	.95	208	1.66	Plains	5,690	12.72	2,075	16.58
1820s	560	1.25	245	1.95	Southeast	16,647	37.22	3,957	31.61
1830s	1,105	2.47	336	2.68	Southwest	16,514	36.92	4,130	33.00
1840s	3,345	7.48	971	7.76	Far West	324	.72	139	1.11
1850s	7,191	16.08	2,035	16.26	Decade				
					Received				
1860s	8,906	19.91	2,316	18.51	1830s	245	.55	144	1.16
1870s	10,870	24.30	2,594	20.73	1840s	243	.54	150	1.20
1880s	8,043	17.98	2,215	17.70	1850s	190	.42	185	1.48
1890s	3,843	8.59	1,400	11.19	1860s	1,224	2.74	424	3.39
1900s	298	.67	141	1.13	1870s	5,607	12.54	1,665	13.30
					1880s	7,577	16.94	1,934	15.45
					1890s	10,785	24.11	2,527	20.19
					1900s	9,979	22.31	2,437	19.47
					1910s	8,762	19.58	3,016	24.11
					1920s	113	.25	32	.26

Source: See Table 1.

Table 2 presents proportions for black inmates' age, birth decade, occupations, and nativity. Although average statures are included, they are not reliable because of possible compositional effects, which are accounted for in the regression models that follow. Age percentages demonstrate that black inmates were incarcerated at younger

ages. Southern law evolved to favor plantation law, which generally allowed slave owners to recover slave labor on plantations while slaves were punished (Komlos and Coclanis, 1997, p. 436; Wahl, 1996, 1997; Friedman, 1993). Blacks were less likely to be incarcerated during the early 19<sup>th</sup> century; however, with passage of the 13<sup>th</sup> amendment, slave owners no longer had claims on black labor, and free blacks who broke the law were turned over to state penal systems to exact their social debt. Most prisoners were born in the mid-19<sup>th</sup> century; occupations reflect socioeconomic status, and while prison inmates typically come from lower working classes, there was a sizeable share of inmates from white-collar and skilled occupations. Most blacks in the sample were born in the lower South and were incarcerated in the late 19<sup>th</sup> century.

#### *United States' Insolation*

To account for the relationship between vitamin D and stature, a measure is constructed that accounts for solar radiation. Insolation is the incoming direct sunlight that reaches the earth, its atmosphere, and surface objects.<sup>4</sup> Insolation is also the primary source of vitamin D (Holick, 1981, p. 590; Holick, 2007, p. 270). Before their forced migration to North America, Africans were exposed to considerable insolation, which was significantly greater than the insolation received by their progeny in the US. Because of its size, Africa has a large insolation variation, and because of its proximity to the equator, its average insolation is greater than the insolation received in the US. For example, from a random sample of western African sites, West Africa receives

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<sup>4</sup> Insolation is an acronym for incident solar radiation, and is a measure for sunlight energy received for a given surface area at a given time. If w equals watts, m equals meters, and i equals insolation,

$$i = \frac{w}{m^2} = \frac{kwh}{m^2 \cdot day}.$$

approximately 5.6 hours of direct insolation per day with a standard deviation of .53 hours; however, the US only receives 4.10 hours of direct sunlight per day with a standard deviation of .61 hours and the difference is significant at acceptable levels.<sup>5</sup>

Because US historical insolation is unavailable, a modern insolation index (1993-2003) is constructed, and monthly insolation values are measured from January through June. The insolation index measures statewide average insolation levels across each of the states based on the hours of direct sunlight per day at county centroids in each state.<sup>6</sup> Each state estimate was then determined by summing the average hours of direct sunlight for each county (at its centroid), weighted by the proportion of the county's total land area (in square miles) to the state's total land area (in square miles). While this index is a rough approximation for historical insolation, it provides sufficient detail to capture state latitudinal insolation variation and consequently, vitamin D production. Predictably, Southern states have greater insolation than Northern states. For example, Texas receives 1.43, or 29 percent, more hours of direct sunlight per day than New York. It is also difficult to interpret insolation's net direct effect on human health, because greater insolation reduces calories required to maintain body temperature and produces more vitamin D, but greater insolation also warms surface temperatures, which may have made

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<sup>5</sup> Western African sites include Ouagadougou, Burkina Faso; Yaoundé, Cameroon; Bangui, Central African Republic; Accra, Ghana; Gambia, Gambia; Conakry, Guinea; Liberia; Nouakchott, Mauritania; Niamey, Nigeria; Freetown, Sierra Leone; Dakar, Senegal.

<sup>6</sup> Insolation is not the insolation in the county that surround's the state's centroid, but insolation in each county's geographic center. The range of state insolation values extends from Maine's minimum of 3.43 hours of direct sunlight to Arizona's maximum of 5.22 hours of direct sunlight per day.

disease environments less healthy from water-born diseases, especially in the South (Steckel, 1992, p. 501).

### III. Socioeconomic Status, Geography, Insolation, and African-American Stature

Nineteenth century black biological living conditions were related to age, socioeconomic status, birth cohorts, and nativity; they were also related to insolation, and vitamin D production. Which of these factors dominates reveals much about 19<sup>th</sup> century conditions facing African-Americans. If nativity within the US was a source for black stature variation, regional social practices were a possible driving force in stature variation. If occupations were associated with black stature, relative social position was an impetus driving black stature variation. If, however, insolation was associated with black stature, part of 19<sup>th</sup> century black stature variation was not social or cultural but geographical, and blacks born in the South would have benefited from extended insolation, even though they faced sub-standard material living conditions and more intense work regimens.

To better understand the interaction between stature and observable characteristics across the stature distribution, a quantile regression function is constructed. Let  $s_i$  represent the stature of the  $i^{\text{th}}$  inmate and  $x_i$  the vector of covariates representing birth cohort, socioeconomic status, and demographic characteristics. The conditional quantile function is

$$s_i = Q_y(p|x) = \theta x + \eta S(p), \quad p \in (0,1)$$

which is the  $p^{\text{th}}$ -quantile of  $s$ , given  $x$ . The coefficient vector  $\theta$  is obtained using techniques presented in Koenker and Bassett (1978) and Hendricks and Koenker (1992). The interpretation of the coefficient  $\theta_j$  is the influence of the  $j^{\text{th}}$  covariate on the stature

distribution at the  $p^{\text{th}}$  quantile. For example, the age coefficient at the median (.5 quantile) is the stature increase that keeps an “average” inmate’s stature on the median if age increases by one year. When estimating stature regressions, quantile estimation offers several advantages over least squares. Two advantages in anthropometric research are more robust estimation in the face of an unknown truncation point and greater description of covariate effects across that stature distribution.

We test which variables were associated with 19<sup>th</sup> century African-Americans stature. To start, stature for the  $i^{\text{th}}$  individual is related to age, socioeconomic status, birth period, nativity, and insolation.

$$\begin{aligned}
 Cent_i = & \alpha + \beta_1^p Black_i + \sum_{a=12}^{70} \beta_a^p Age_i + \sum_{t=1}^{10} \beta_t^p Birth\ Decade_i + \sum_{l=1}^3 \beta_l^p Occupation_i \\
 & + \sum_{n=1}^6 \beta_n^p Nativity_i + \beta_{Migration}^p Migration_i + \sum_{d=1}^4 \beta_d^p Move\ Direction_i + \beta_{Insol}^p Insolation_i \\
 & + \beta_{Mulatto \times Insol}^p Mulatto \times Insolation_i + \varepsilon_i^p
 \end{aligned}$$

Dummy variables are included for individual youth ages 14 through 23; adult age dummies are included for ten year age intervals from the 40s through the 70s. Birth decade dummies are in ten year intervals from 1800 through 1899. Occupation dummy variables are for white-collar, skilled, agricultural, and unskilled occupations. Nativity dummy variables are included for birth in Northeast, Middle Atlantic, Great Lakes, Southeast, Southwest, and Far West regions. A dummy variable accounts for migration status and directional migration dummy variables are included to account for North-South migrations.<sup>7</sup> If insolation was a driving force in stature growth, northward moves

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<sup>7</sup> North1 is an intermediate move from Southern to Central or Central to Northern states. North2 is a long distance move from Southern to Northern states. South1 is a move from a Northern to Central or Central to

will have adverse stature effects, and southward moves will be associated with taller statures. Continuous insolation and insolation difference variables between receiving and sending locations are added to account for insolation and vitamin D production. Lastly, a race and insolation interactive variable is included to account for racial differences between how blacks and mulattos process vitamin D.

Table 3's model 1 presents least squares estimates for the black and mulatto pooled sample; models 2 through 6 illustrate how stature was related to demographic, occupation, nativity, migration, and insolation variables across the stature distribution. Models 7 and 8 present black and mulatto least squares regression models used in the stature decomposition in the next section.

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Southern state. South2 is a move from Northern to Southern states. Northern states include Maine, Vermont, New Hampshire, Massachusetts, Connecticut, Rhode Island, New York, New Jersey, Pennsylvania, Michigan, Wisconsin, Iowa, Minnesota, North Dakota, South Dakota, Wyoming, Montana, Idaho, Oregon, and Washington. Central states include Delaware, Maryland, Virginia, West Virginia, Kentucky, Indiana, Illinois, Missouri, Nebraska, Kansas, Colorado, Utah, Nevada, and California. Southern states include North Carolina, South Carolina, Georgia, Florida, Alabama, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma, Texas, New Mexico, and Arizona. The binary variable North1 is an intermediate move from Southern to Central or Central to Northern states. North2 is a long distance move from Southern to Northern states. South1 is a move from a Northern to Central or Central to Southern state. South2 is a move from Northern to Southern states.



Table 3, National Quantile Stature Models related to Demographics, Birth Period, Migration, and Insolation by Socioeconomic Status

	<i>Model 1</i>	<i>Model 2</i>	<i>Model 3</i>	<i>Model 4</i>	<i>Model 5</i>	<i>Model 6</i>	<i>Model 7</i>	<i>Model 8</i>
	<i>OLS</i>	<i>.25</i>	<i>.50</i>	<i>.75</i>	<i>.90</i>	<i>.95</i>	<i>Blacks</i>	<i>Mulattos</i>
Intercept	166.27***	160.71***	166.25***	171.32***	173.52***	176.99***	165.81***	170.76***
<i>Complexion</i>								
Black	Reference	Reference	Reference	Reference	Reference	Reference		
Mulatto	3.19***	4.10***	3.21***	2.17***	3.32***	3.03***		
<i>Ages</i>								
14	-11.08***	-10.71***	-11.19***	-10.49***	-9.55***	-9.37***	-11.68***	-8.82***
15	-8.42***	-7.74***	-8.22***	-7.91***	-7.67***	-8.58***	-8.24***	-9.07***
16	-5.46***	-5.23***	-5.31***	-5.41***	-5.15***	-5.56***	-5.45***	-5.49***
17	-3.35***	-2.77***	-3.34***	-3.91***	-3.47***	-3.66***	-3.33***	-3.40***
18	-2.47***	-2.47***	-2.49***	-2.62***	-2.61***	-3.02***	-2.58***	-2.03***
19	-1.42***	-.915***	-1.43***	-1.53***	-1.29***	-1.63***	-1.35***	-1.60***
20	-.485***	-.272*	-.225*	-.635***	-.362	-.480***	-.564***	-.208
21	-.354***	-.357**	-.083	-.255*	-.021	-.022	-.393***	-.208
22	-.203*	-.025	-.206	-.402**	-.021	.003	-.311**	.170
23	-.008	-8.6 <sup>-8</sup>	-2.4 <sup>-7</sup>	9.7 <sup>-8</sup>	-.021	-.160	.015	-.080
24-29	Reference	Reference	Reference	Reference	Reference	Reference	Reference	Reference
40s	-.546***	-.550***	-.392***	-.693***	-.363*	-.635***	-.547***	-.507*
50s	-1.00***	-.736***	-1.24***	-1.18***	-.343	-.177	-1.21***	.053
60s	-1.72***	-1.89***	-1.82***	-1.64***	-1.92***	-2.36***	-1.66***	-1.89***
70s	-2.42***	-1.98**	-2.27***	-2.25***	-3.83***	-4.33***	-2.73***	1.26
<i>Birth Decade</i>								
1800s	.387	.656	.818	.496	-.216	-.432	.685	-.451
1810s	.685**	.708**	.707**	.663	1.02*	1.26***	.619*	1.01**
1820s	-.202	-.562*	-.208*	.170	.013	-.500	-.626**	.959**
1830s	-.313	-.313	.052	.121	-.297	-.638**	-.552**	.484



$R^2$	.0780	.0450	.0362	.0362	.0390	.0390	.0786	.0784
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Source: See Table 1.

Notes: Stature is in centimeters. Youth age is between ages 15 and 22. The occupation classification scheme is consistent with Ferrie (1997); The following geographic classification scheme is consistent with Carlino and Sill (2000): New England= CT, ME, MA, NH, RI and VT; Middle Atlantic= DE, DC, MD, NJ, NY, and PA; Great Lakes= IL, IN, MI, OH, and WI; Plains= IA, KS, MN, MO, NE, ND, and SD; South East= AL, AR, FL, GA, KY, LA, MS, NC, SC, TN, VA, and WV; South West= AZ, NM, OK, and TX; Far West= CA, CO, ID, MT, NV, OR, UT, WA, and WA. Stature difference is average white stature less average black stature. \*-1 percent significant; \*\*-5 percent significant; \*\*\*-10 percent significant. Standard errors attained with bootstrap.

Two general patterns emerge when assessing 19<sup>th</sup> century black stature. First, consistent with the stature-insolation hypothesis, mulattos, who have less melanin in their stratum corneum and produce more vitamin D, were over three cms taller than darker pigmented blacks (Loomis, 1967, pp. 501-504; Neer, 1979, p. 441). Tests for insolation's affect across the stature distribution illustrate the amount of sunlight was positively associated with black stature, and blacks in lower stature quantiles received significantly larger stature returns from insolation than blacks in higher stature quantiles (Koenker, 2005, pp. 75-76; Koenker and Bassett, 1982). Moreover, the positive coefficient on the insolation difference variable between sending and receiving locations indicate that for each additional hour of sunlight, blacks were nearly one and a half cms taller than non-migrants. The mulatto and insolation interactive term illustrates that because of their darker pigmentations, blacks received larger stature returns than mulattos for the same hour of direct sunlight. Therefore, insolation and vitamin D probably influenced 19<sup>th</sup> century black stature, which is supported by modern population studies (Norman, 1998, pp. 1108-1110; Weisberg et al, p. 1703S-1704S; Holick, 1995, pp. 641S-642S; Nesby-O'Dell et al 2002, p. 189).

Two explanations are offered for this pigmentation effect. First, mulattos were taller than their darker colored counterparts because 19<sup>th</sup> century US social practices favored lighter colored blacks, and mulattos received superior diets, less intense work regimens, or faced less violence and hostility because of their lighter pigmentation (Steckel, 1979, pp. 374-376; Margo and Steckel, 1982, pp. 516-538; Bodenhorn, 1999). Second, mulattos were taller than their darker colored counterparts because mulattos produce more vitamin D in their stratum granulosum because of less melanin in the

stratum corneum (Carson, 2008, pp. 821-825). The positive and significant insolation coefficient indicates blacks were, at least in part, taller because they were exposed to more insolation and produced more vitamin D.

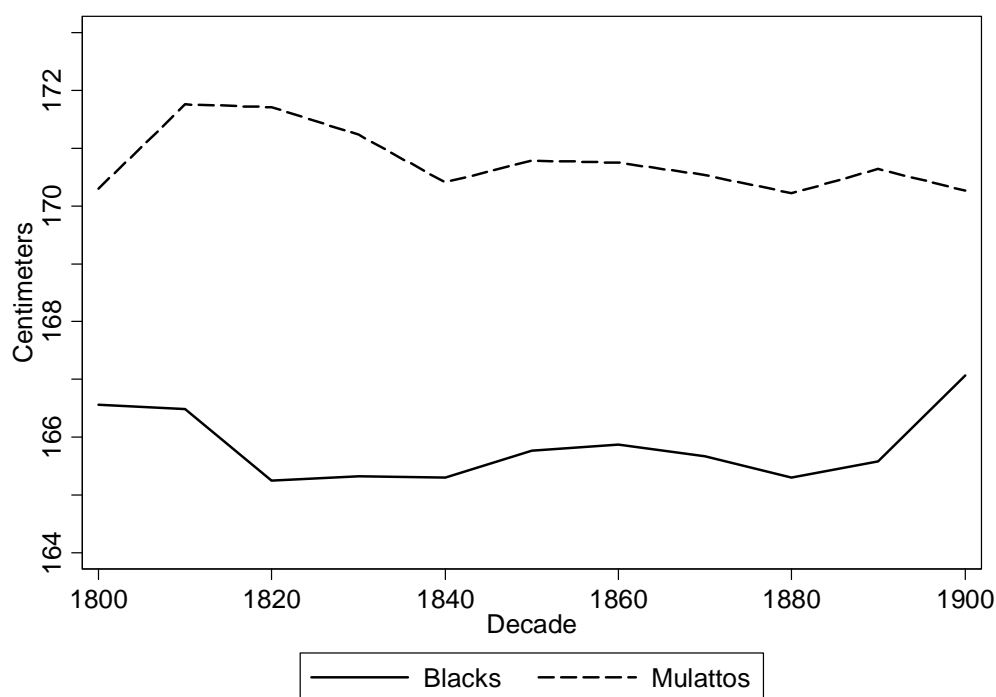


Figure 1, Nineteenth Century Black and Mulatto Statures over Time

Source: See Table 3's black and mulatto models.

Second, both black and mulatto statures were taller at the beginning of the 19<sup>th</sup> century, declined by about one centimeter by 1840, and increased during the final years of the antebellum period (Figure 1), which is consistent with the Komlos-Rees hypothesis that black statures increased during the antebellum period and declined, at least temporarily, during the post-bellum period (Tables 3 and Figure 2; Komlos, 1998; Rees

et al, 2003; Carson, 2008).<sup>8</sup> Darker black statures decreased after the Civil War by more than the stature declines experienced by mulattos but experienced a larger recover during the 1890s. After slavery, blacks were exposed to greater income variation and were ill-prepared for life beyond slavery, either in terms of experience or human capital. Statures in the late 19<sup>th</sup> century probably increased with higher black incomes, and blacks in the post-bellum period devoted a higher share of their incomes to food acquisition (Higgs, 1977, pp. 102-105). Moreover, stature by birth year had the smallest variation at lower quantiles (Figure 2), suggesting that black statures at biological subsistence did not vary over the course of the 19<sup>th</sup> century. On the other hand, because they escaped biological subsistence conditions, blacks in higher stature quantiles were more vulnerable to changes in the economic environment, which is illustrated by larger stature variation at higher black stature quantiles.

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<sup>8</sup> Larger standard deviations for the 1850 and 1860 cohorts in Table 2 may be a function of changing statures from shifting labor market institutions in the South during these decades.

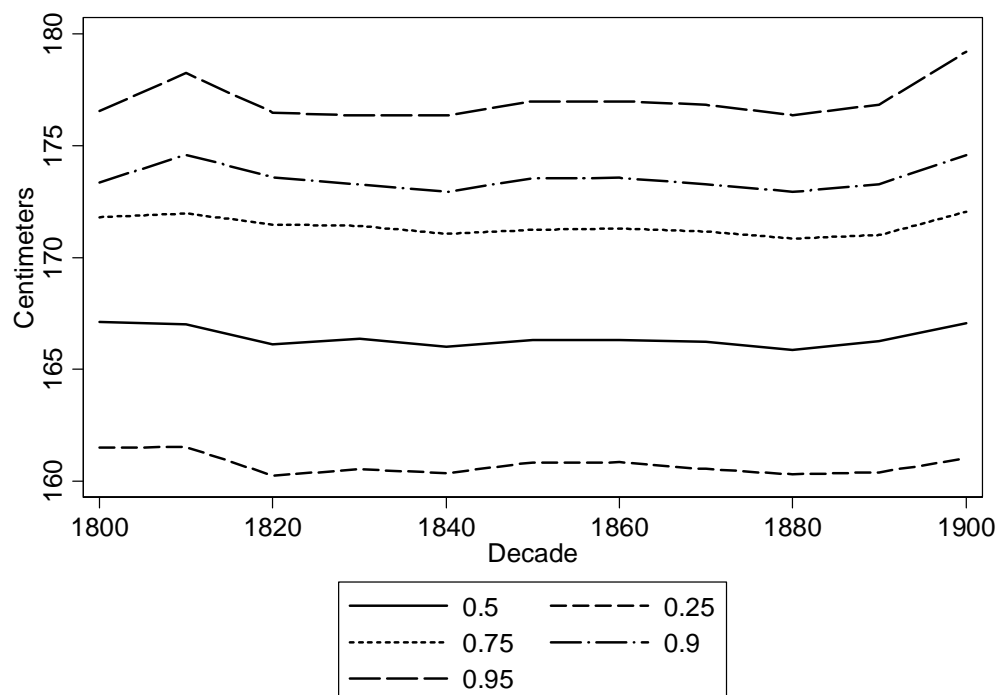


Figure 2, Nineteenth Century African-American across Quantiles

Source: See Table 3.

For several other categories, expected patterns hold. Farmers were taller than non-farmers, and farmers benefited from their close proximity to nutritious diets and mild disease environments; average unskilled workers and field hands were also taller than household servants and skilled slaves (Metzer, 1975, p. 134; Margo and Steckel, 1982, p. 525). Moreover, tests for the relationship between stature and occupations across the stature distribution illustrate that black farmers in lower stature quantiles were more positively influenced by their rural environments than black farmers in higher stature quantiles (Koenker, 2005, pp. 75-76). Workers in occupations with greater exposure to direct sunlight may have also grown taller because they were exposed to greater

insolation as children and produced more vitamin D, which contributed to healthy bone formation (Tortolani, 2002, pp. 57-61; Bodiwala, et al, 2003, pp. 659-660; Tangpricha, et al, 2002, p. 662; Holick, 1981, p. 590). Islam et al. (2007, pp. 383-388) demonstrates that children exposed to more direct sunlight produce more vitamin D, and if there was little movement away from parental occupation, 19<sup>th</sup> century occupations may also be a good indicator for the occupational environment in which individuals came to maturity (Margo and Steckel, 1992, p. 520; Wannamethee et al, 1996, pp. 1256-1262; Nyström-Peck and Lundberg, 1995, pp. 734-737).

Black statures also varied regionally, and Southwestern blacks reached the tallest statures. During the antebellum period, slaves were shielded from income and price variation, and although Southwestern slavery was arduous and demanded more calories for work, Southwestern blacks lived in more recently settled and productive farmlands (Komlos and Coclanis, 1997, p. 443). Southern wages were in general lower than Northern wages. However, 19<sup>th</sup> century West South Central laborers' wages were comparable to those in the middle Atlantic region, and after emancipation Southwestern black wages were higher than elsewhere, which may have improved Southern black material and biological conditions (Rosenbloom, 2002, pp. 53, 124-125; Margo, 2000; Higgs, 1977, pp. 26, 63 and 102). The relative price of dairy and calcium were also lowest in dairy producing regions, such as the Great Lake states, but 19<sup>th</sup> century blacks were overwhelmingly native to the South, and the South was notoriously low in dairy production.<sup>9</sup> Northeastern blacks, especially youth, encountered adverse biological

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<sup>9</sup> Southern observers at the time reported that milk was fairly abundant in border states but in short supply in the Deep South (Kiple and King, 1981, p. 83; Baten and Murray, 2000, pp. 359-360).



environments, and contemporary reports of rickets—a result of childhood vitamin D deficiency—may have contributed to shorter Northeastern black statures (Kiple and Kiple, 1977, p. 293-294; Tortolani et al, 2002, p. 62).

#### IV. Explaining the Relative Mulatto Stature Advantage

To more fully account for the source of the mulatto-black stature differential and to isolate the relative importance of insolation on black stature, a Blinder-Oaxaca decomposition is imposed on the mulatto-black stature differential (Oaxaca, 1973). Let  $S_m$  and  $S_b$  represent the statures of mulattos and blacks, respectively;  $\alpha_m$  and  $\alpha_b$  are the autonomous stature components that accrue to mulattos and blacks;  $\beta_m$  and  $\beta_b$  are the mulatto and black stature returns associated with specific stature enhancing characteristics, such as age and occupation.  $X_m$  and  $X_b$  are mulatto and black characteristic matrices, and mulatto statures are assumed to be the base structure.

$$\Delta S = S_m - S_b = (\alpha_m - \alpha_b) + (\beta_m - \beta_b)X_b + \beta_m(X_m - X_b)$$

The second right hand-side element is that component of the stature differential due to differences in stature returns and for most characteristics was likely positive. If, however, blacks at North American latitudes received larger stature gains from insolation than mulattos, the returns from the stature gap due to insolation will be negative. The third right-hand side element is the component due to differences in characteristics. Therefore, if mulatto stature advantages were due to inferior darker black biological conditions, the stature returns to mulattos,  $\beta_m$ , will be larger than stature returns to blacks,  $\beta_b$ .

Table 4, Nineteenth Century National Prison Stature Oaxaca Decomposition

	$(\beta_M - \beta_B)\bar{X}_B$	$\beta_M(\bar{X}_M - \bar{X}_B)$
Levels		
Sum	.619	-.184
Total		.435
Proportions		
Intercept	11.38	
Ages	.274	-.008
Birth Year	.217	.033
Occupations	.156	-.095
Nativity	8.7 <sup>-4</sup>	-.397
Migration	-.209	-.004
Insolation	-10.39	.044
Sum	1.42	-.423
Total		1

Source: See Table 3.

Note: Oaxaca results derived from Table 3's black and mulatto models.

Using coefficients from the black and mulatto stature regressions (Table 3, Models 7 and 8), a stature decomposition indicates that the majority of the stature gap arose from non-identifiable characteristics, such as better nutrition and higher socioeconomic status that disproportionately favored mulattos (Table 4); moreover, the majority of the stature differential due to observable characteristics is associated with age and insolation. Measured in levels, the share of the stature gap attributable to characteristics illustrates that 19<sup>th</sup> century blacks lived in areas that received more

insolation.<sup>10</sup> Measured in proportions, black returns to insolation at North American latitudes were greater than mulattos. Therefore, at North American latitudes, darker black stature gains from insolation were larger than for mulattos, and blacks lived in states that received more insolation; however, the majority of the mulatto-black stature differential is explained by non-identifiable characteristics, but insolation was the primary factors among observable characteristics.

## V. Conclusions

This paper identifies insolation as an important source for 19<sup>th</sup> century black and mulatto stature variation and illustrates that at North American latitudes the two groups responded differently to insolation affects and vitamin D production. Mulattos were taller than darker pigmented blacks; however, the marginal impact of insolation on darker pigmented black statures was greater than for mulattos. Part of this difference was related to melanin in the stratum corneum, which allowed for greater mulatto vitamin D production, subsequently, taller statures. Therefore, part of the observed 19<sup>th</sup> century mulatto stature advantage is attributable in biological differences between how blacks and mulattos process vitamin D.

Consistent with the Komlos-Rees hypothesis, black statures increased during the antebellum period and declined in the post-bellum period. The stature-insolation hypothesis also adds to our knowledge for why 19<sup>th</sup> century farmers were taller than workers in other occupations. Farmers were undoubtedly closer to nutritious food

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<sup>10</sup> Blacks in the prison sample lived in states that received 4.37 hours of direct sunlight per day compared to whites in the sample who lived in states that received 3.95 hours of sunlight per day, or blacks lived in states that received about 11 percent more insolation than whites.

supplies and farther from crowded urban locations, where disease was most easily propagated. However, farmers were also exposed to more sunlight, produced more vitamin D than their white-collar and skilled counterparts, and reached taller terminal statures. Therefore, rather than only sociological processes and access to nutrition explaining the stature difference between blacks and mulattos, part of the difference may be biologically based.

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