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On the Size of Horses during the Industrial Revolution

Abstract: We estimate a decline in the size of horses of about 1.9 cm at the end of the 18th c. - about one standard deviation of their size distribution. This finding has implications for our understanding of the development of agriculture during the period, insofar as the inference is warranted that the size of other livestock might well have experienced similar trends during the period. This implies, in turn, that the yield of meat and milk per livestock might have fallen during the period of the Industrial Revolution. Hence, the production of meat and dairy products was probably less than has been estimated hitherto. Moreover, the argument is advanced that the positive correlation between the trend in the physical size of horses and that of soldiers corroborates indirectly the notion that the contemporaneous diminution in nutritional status among humans was related to the decline in the per-capita intake of nutrients, rather than by a deterioration in the disease environment. This is the case, because humans and animals competed for nutritional resources, and for pasture land that could be plowed under for grain production, and because the nutrient resources available to both were affected by climatic trends. In contrast, the hypothesis that the worsening epidemiological environment caused the diminution in human physical stature receives no support from the evidence at hand, because horses would have been immune to the disease vectors affecting human populations, and hence their size would have remained unaffected by a worsening human disease pool.

The widespread and substantial decline in the physical stature of Europeans during the course of the eighteenth century has been attributed primarily to economic processes unleashed by the demographic revolution and subsequent industrialization, which made it increasingly difficult to maintain the nutritional status of the population. Technological change and capital accumulation in the agricultural sector did not keep pace with the unprecedented acceleration in the rate of population growth,[1] and a marked decrease in calorie and protein intake, particularly from animal sources became evident.[2] The worsening weather conditions acerbated the problem considerably through their impact upon the harvest. Through its effect on the output of pasture land, i.e., on animal fodder, the weather also had an indirect impact on the amount of milk and dairy products available for human consumption.[3] Yet, the epidemiological environment might have also worsened during the period with an adverse effect on the height of Europeans, insofar as sickness encounters slow the rate of nutrient absorption of the human organism, and consequently, less energy would

have been available for physical growth. Moreover, there might have been interaction effects among these factors, particularly since nutritional status and diseases affect one another in a synergistic fashion. Those weakened by nutrient deficiencies may be particularly susceptible to disease agents.

The argument has been advanced that the epidemiological factor was not likely to have been the sole cause of the diminution in physical stature: there is evidence that the aristocracy was exempt from the above-mentioned nutritional downturn, probably because their income sufficed to maintain their nutritional status even in face of the increasing scarcity of nutrients. If the disease environment had deteriorated, with the other two factors remaining unchanged, one would expect that the aristocracy would have been subject to increased morbidity as well, and the height of all members of the society would have declined.[4] In addition, mortality should have increased during this period if endemic of epidemic diseases were becoming more virulent or encounters more frequent. Insofar as mortality rate did not rise, the inference is warranted that the epidemiological conditions probably did not worsen substantially, and the diminution in heights cannot be explained solely on the basis of a rise in disease encounters.

The determination of such causal relationships using controlled experiments are, of course, impossible in a historical context, and therefore the inferences in a such a complex chain of reasoning must perforce remain fragile. Hence, we continually search for supporting circumstantial evidence that might illuminate the issues at hand. One such set of extant data pertains to the size of horses. As the food grown for human consumption, the amount of animal feed, too, was subject to the vagaries of weather conditions. If these had worsened, the output of hay and that of pasture grasses would have declined as well, impinging on the feed available for livestock, including horses. Additionally, horses also competed with humans for the available stock of nutrients, insofar as both were able to ingest oats, an inferior grain, but consumed to some degree among the poor. Hence, if the nutritional status of the European

population was reaching precarious levels, some nutritional resources would have been diverted from animals to humans. Thus, a decline in the size of horses would provide corroborating evidence that the diminution in human physical stature was related to a decline in food consumption.

In contrast, a hypothetical increase in the severity of human diseases would have left horses unscathed. Hence, if the size of horses remained constant, or if it increased during the era of the Industrial Revolution, then the possibility would increase that the decline in human height was not induced by a decline in nutrient intake, i.e., that it might have been brought about by an increased incidence of diseases affecting the human population.

We explore this hypothesis on the basis of the size of horses of the 4th Austrian Dragoons Regiment.[5] The number of data collected is 5,948. The age of the horses in the sample ranged from 3 to 22 years (average = 9.7 years), born between 1762 and 1816.[6] As the soldiers, the horses, too, were subject to a size requirement. In the case of horses, the minimum and maximum size requirement (MSR) in this period ranged from 58 to 60 Austrian inches (A.i.) (152.7-158.0 cm).[7] We note, that the effective MSRs were even more limiting than the official ones, because a negligible number of horses in the 58 A.i. category were purchased by the military, except during the final years of the Napoleonic Wars (Table 1). In order to keep the effective MSR constant, we truncate the data below 59 and above 60.75 A.i. (155.3-160.0 cm).[8] Though this confines our observations to a rather narrow band of 4.7 cm, this assures us that the obtained trend is not caused by the variations in the enforcement of the MSRs.

Using regression analysis with quinquennial dummy variables to estimate the trend, we obtain a substantial decline in the first half of the 1770s, which coincided with a subsistence crisis of major proportions felt well beyond the geographic confines of Central Europe.[9] After a temporary recovery in the second half of the decade, a statistically significant decrease in the size of the horses is evident (Figure 1 and Table 2 column 1). The decline is

estimated to have been 0,86 cm between the peak in 1775-79 and the through in 1790-94. While this decrease is not particularly large by any means, it does appear much more impressive if we consider the relatively small range to which the size of military horses was confined: some 4.7 cm.[10] We need to estimate how much the population of all horses – from which the military horses were drawn – declined. We estimate that a diminution of 0.86 cm among military horses implies that the mean of the population of all horses, including civilian ones, from which the horses were drawn, must have declined by more than twice as much, i.e., by 1.9 cm.[11] This is on the order of magnitude of about one standard deviation of the size distribution of horses. A comparable one standard deviation decrease among humans would have been 6.8 cm, a substantial decline, indeed.

Furthermore, it is worthy of note that a distinctly positive correlation between the trend in the size of horses and that of the physical stature of soldiers in the monarchy is evident[12] (Figure 2). Both series have a negative trend during the two decades subsequent to 1775, and both trends reverse direction subsequently.[13] The heights of soldiers were lagged by a decade so that the date of birth of the horses corresponds approximately to the adolescent growth spurt of the soldiers with whom they are being compared. Obviously humans and horses have different growth spans, and are therefore subject to different environmental influences. But the adolescent growth period is clearly a period in which human growth is quite sensitive to nutritional influences, so that the correlation between the two series with a decade lag is by all means understandable. The fact that the diminution in the height of Hungarian soldiers was greater (3.1 cm) than that experienced by horses (1.9 cm) is (perhaps) an indication of the greater plasticity of the human species in response to environmental stress.[14]

The decline in the size of horses at the end of the 18th century has broader implications beyond anthropometric history, in particular for agricultural history of the era. This is the case, because it would be reasonable to assume that the size of other livestock, including

cattle, might well have experienced similar evolution during the period considered. In turn, this would imply that the yield of meat and milk per livestock would have fallen as well. Hence, the production of meat and dairy products was quite probably less than hitherto supposed throughout Europe. This would have two immediate consequences for our understanding of the economic history of the period. It would mean that agricultural productivity might well have been overestimated, based as it was on constant yields per head of livestock, and analogously, that the availability to Europeans of protein-rich food products declined by more than hitherto thought.[15]

The conclusion is warranted, that the close correspondence between the decline in the size of horses and in the height of human populations during the Industrial Revolution period corroborates indirectly the notion that the diminution in nutritional status among humans at the end of the eighteenth century was related to the decline in the per-capita intake of nutrients, rather than by a deterioration in the human disease environment. This is the case, because man and animals competed for nutritional resources, and for pasture land that could be plowed under for grain production, and because the nutrient resources available to both were affected by climatic trends. In contrast, the hypothesis that the worsening epidemiological environment caused the diminution in human physical stature receives no support from the evidence at hand, because horses would have been immune to the disease vectors affecting human populations, and hence their size would have remained unaffected. Yet, their height did decline. One would have to argue that the incidence or virulence of diseases affecting horses increased in tandem with those diseases affecting humans. This is unlikely, particularly since both the size of horses and physical stature of humans recovered much of their losses after the Napoleonic Wars, and there is no plausible reason to think that the epidemiological environment worsened temporarily only to improve again. To be sure, synergistic effects have not been ruled out in our consideration. Hence, it is possible that the decline in nutrient intake in both humans and horses made them both more susceptible to

disease encounters. Admittedly circumstantial, and perhaps not incontrovertible, the evidence at hand, nonetheless, does not allow us to reject the hypothesis that the threatening Malthusian crisis affected both humans and domesticated animals living in a close symbiotic relationship with their natural environment.

Table 1. Distribution of the Size of Horses by Purchase Date (Percent)

	Austrian inches			
	58	59	60	N
1774-1791	7.2	36.0	56.8	1576
1792-1808	4.1	56,5	39,4	1839
1809-1815	17.3	42.1	40.6	266
1816-1820	1.4	17,9	80,7	145

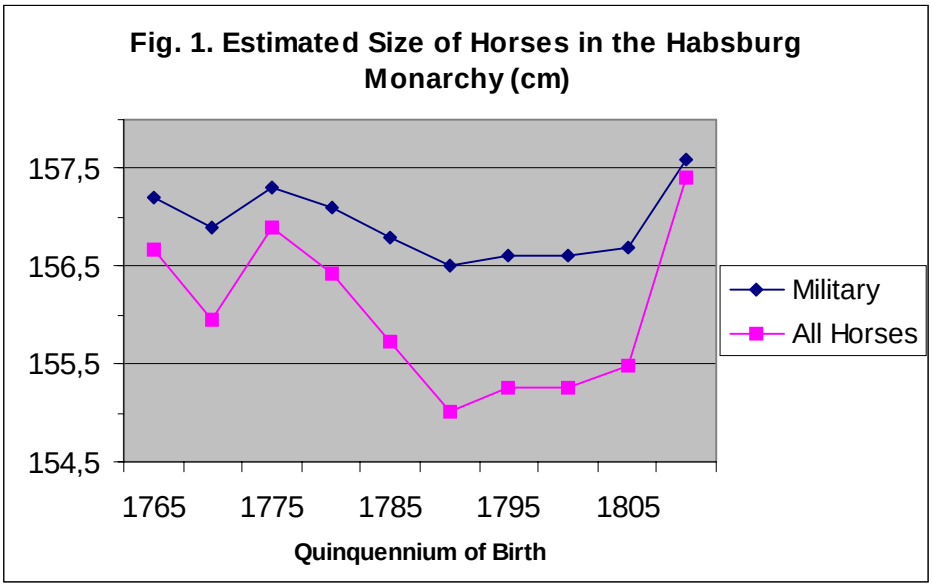
Table 2. Size of Horses in the Habsburg Military (cm)

Date of Birth	Truncated Mean	Estimated Population Mean
1760s	157.2	156.7
1770-74	156.9*	156.0
1775-79	157.3	156.9
1780-84	157.1*	156.4
1785-89	156.8*	155.7
1790-95	156.5*	155.0
1795-99	156.6*	155.2
1800-04	156.6*	155.2
1805-09	156.7*	155.5
1810s	157.6*	157.4
R^2	0.07	
F	39.1*	
N	4536	

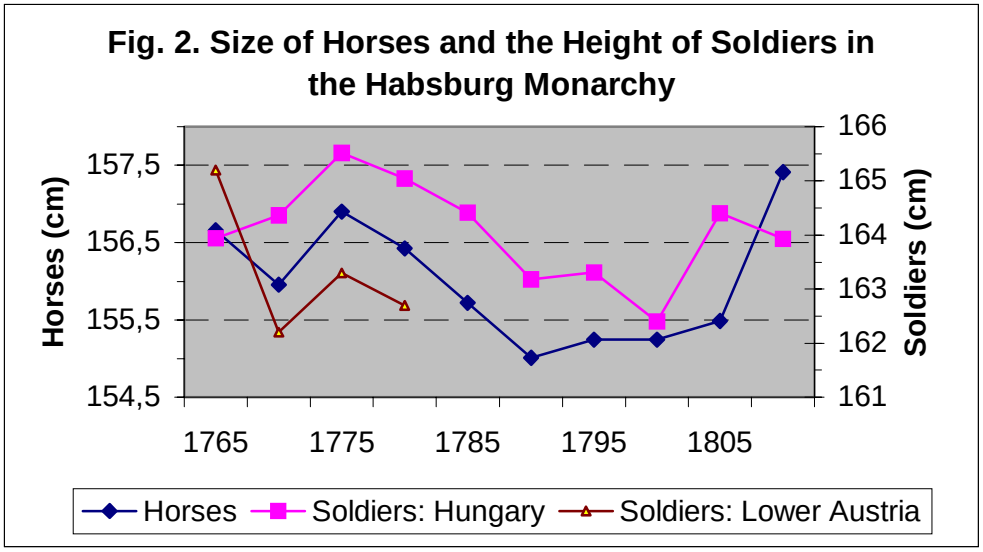
Note: In order to maintain the MSRs constant, the analyzed data were confined to the range of 59- 60.75 A.i. in the first column.
* signifies that the coefficient is significantly different (at the 10 percent level) from that of the 1775-79 period in case of birth-date variables.

Source: Österreichisches Staatsarchiv, Kriegsarchiv, Musterlisten, Dragoner Regiment Nr. 4,

1781-1820.



Source: See Table 1.



Sources: See Table 1, and John Komlos, Nutrition and Economic Development in the Eighteenth Century Habsburg Monarchy (Princeton University Press, 1989), p. 57.

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Endnotes

[1] Komlos, J. „Shrinking in a Growing Economy? The Mystery of Physical Stature during the Industrial Revolution," Journal of Economic History 58 (1998) 3: 770-802.

[2] Wages of day laborers in Vienna could purchase one-third less bread in the 1780s than half a century earlier. Roman Sandgruber, Anfänge der Konsumgesellschaft (Vienna: Verlag für Geschichte und Politik, 1982), p. 115.

[3] Baten, J. Ernährung und wirtschaftliche entwicklung in Bayern Stuttgart: Franz Steiner, 1999, p. 52.

[4] Admittedly, it is possible that disease conditions worsened, but aristocratic incomes increased sufficiently to maintain their nutritional status at a constant level.

[5] As numeracy spread in Europe, data on the size of horses was probably collected by many cavalry units in the eighteenth century.

[6] Österreichisches Staatsarchiv, Kriegsarchiv, Musterlisten, Dragoner Regiment Nr. 4, 1781-1820. About a third of the data set pertains to mares and the rest to geldings (castrated stallions). There was no difference in their height. Until 1798 the regiment was designated as „Chaveuxleger" for whom the 58-60 Austrian inch requirement was effective. Thereafter it became a dragoon regiment for which the MSR was lower, namely 56.5 Austrian inches. However, the distribution of the size of horses indicates that this change in the designation of the regiment and in the regulations was not enforced in the field. The share of the horses below 58 A.i. remained a negligible, 4.4 percent (up however, from 2.0 percent). Horses were measured at the top of the shoulder blade.

[7] An Austrian inch equals 2.633 cm. We use 160.0 cm (60.75 A.i.) as the upper limit instead of 158.0 cm, because we assume that the maximum size was interpreted as being below 61 A.i.. On the size requirements see Alphons Freiherr von Wrede, Geschichte der k. und k. Wehrmacht Vienna: C.W. Seidel, 1898, p. 115.

[8] Truncating the distribution in this way obviously has an effect on the means, but gives an accurate estimate, of the direction of the trend. John Komlos and J.H. Kim, "Estimating Trends in Historical Heights," Historical Methods 23 (1990): 116-120.

[9] The extremely cold winters of 1771 and 1772 were followed by poor harvests as far away from the Monarchy as Sweden. Gustaf Utterström, „Some Population Problems in Pre-industrial Sweden," Scandinavian Economic History Review 2 (1954): 103-65.

[10] Information is also available on the date of purchase of the horses by the military on a subset of 4,367 observations. We can include this variable to test whether the selectivity within the range of minimum and maximum size requirements were varied over time, particularly during wars. That is to say, were horses born in 1770 but purchased during war time different size from those horses born during the same year, but purchased during peace time? In order to test this hypothesis, we include dummy variables in the regression for the date of purchase during the Napoleonic Wars (dividing the period of conflict into three phases), and for the subsequent peace. (The War of Bavarian of Succession (1778-1779) was of short duration and preliminary analysis showed that the size of horses purchased during the conflict did not change at all.) The results (not reported here) indicate that after the outbreak of the French Wars in 1792, understandably slightly smaller horses were purchased by the military. During the final phase of the conflict, however, the size of horses was raised by few millimeters, though this must be just a statistical artefact, due to the fact that horses in the 58 A.i. category were excluded from the regression. After Waterloo, again understandably, the size of horses selected by the military increased by a few millimeters. The negative trend

obtained with this model is slightly greater, and persists somewhat longer than the estimate reported in Table 2. We do not report this result here, because it does not illuminate the results to any meaningful extent.

[11] We assumed that the standard deviation of the distribution of the size of horses was about one-fourth that of men, i.e., about 1.7 cm. We did a simulation exercise in which we generated 100,000 random numbers with mean μ and $\sigma = 1.7$ cm. We then truncated the distribution between 155.3-160.0 cm, discarding all observations above and below this range, and calculated the mean of the truncated sample. We then repeated the exercise in μ -0.1cm intervals until we found all the values of μ corresponding to the truncated means in Table 1, column 1. In this way we estimate how much the population mean has to change in order to shift the truncated mean by 0.86 cm. If we had assumed that σ were greater than 1.7 cm for horses, then the shift in μ would have had to have been even greater than 1.9 cm.

[12] Correlation between the soldier's height (lagged by a decade) and the truncated means of the horses equals +0.54, p=0.11, N=10; and between the former and the estimated population means of the horses equals +0.58, p=0.08, N=10.

[13] A French physician observed not long after the period under discussion here, that „since a long time," the variations in the size of domestic animals were similar to those of men, namely, that „physical stature is greater, and men grow faster, the wealthier is the region; in other words, misery produces short people, and delays the achievement of final height." L. R. Villermé, „Mémoire sur la Taille de L`Homme en France," Annales D'Hygiène Publique et de Médecine Légale 1 (1829): 351-397, here p. 395.

[14] Stanley J. Ulijaszek, Francis E. Johnston, and Michael A. Preece (eds.), „General Introduction," The Cambridge Encyclopedia of Human Growth and Development, Cambidge, England: Cambridge University Press, 1998, p. 1.

[15] For example, the consumption of meat per capita is estimated to have declined in Rome in the course of the eighteenth century from 31 to 23 kg per capita. Jacques Revel, „A Capital

City’s Privileges: Food Supply in Early-Modern Rome," In Robert Forster and Orst Ranum (eds.), Food and Drink in History (Baltimore: The Johns Hopkins University Press, 1979).