# Stature, nutritional availabilities and population censuses in 19th-century -Algeria: a calling into question of the classic vision of demographic history

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**Abstract**

The demographic history of nineteenth-century Algeria is poorly known and the subject of lively debate between "colonial" and "postcolonial" historians. Yacono (1954) claimed the Algerian population stood at three million in 1830 and then went into decline until the trend reversed in the early 1870s thanks to growth rates unequalled until the postcolonial period (H1). This generally accepted interpretation has been challenged by "postcolonial" historians (Sari, 1982, Kateb, 2001) who argue that the population numbered at least four million in 1830 and stagnated during the 1870s and 1880s (H2). In an attempt to settle the debate, I have reconstructed the height trend of the native population of Algeria from the roll-number of tirailleurs (random samples, N = 11,992) and constructed models using socioeconomic and demographic variables.

Statistical analysis reveals that previously stagnant heights increased during the 1860s, 1870s, and 1880s birth decades. Yet H1 argues that difficulties increased in the 1870s and 1880s: official census records report *per capita* grain production declined until 1886 (unanimously taken as the year of the first reliable census). Nor can the height increase be explained by improvement in the epidemiological context (malaria) or by a shift in the population recruited. However, correlations can be observed between rainfall and stature and between available calories and stature for H2 but not H1, which is consequently rejected. It seems Algeria was more populous in 1872 than colonialist historians claimed, and so the size of the population in 1830 must be revised upward to at least 4.2 million.

**Keywords**: height, Algeria, colonization, nutrition, anthropometrics, census.

## 1. Introduction: colonial crisis *vs* Ancien Régime crisis[i]

Since Brennan's pioneering work in the 1990s on British India, historians with an interest in anthropometry have been studying the evolution of the biological standard of living during periods of colonization with a focus on Asia (Brennan, McDonald & Shlomovitz, 1997, Gill, 1998, Olds, 2003, Morgan & Liu, 2007, Bassino & Coclanis, 2008, Choi & Schwekendiek, 2009, Moradi 2009) while Africa has remained the discipline's blind spot. This study attempts to fill in a few of the blanks on the map by reconstructing the height trends in one of the former French colonies. Algeria is a particularly interesting case in that it was the pride of the French colonial empire and the only one of France's colonies that was set up for the purposes of settlement by Europeans, therefore known as *colons*. Moreover, abundant anthropometric source material dating from the start of colonization is available for Algeria.

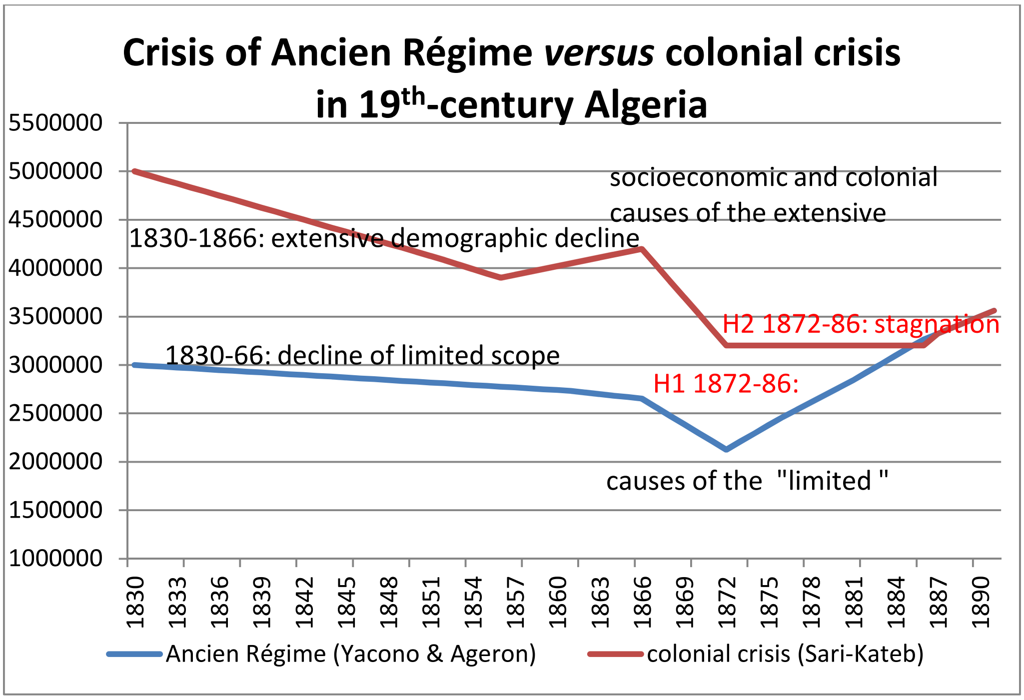
Indeed, it is all the more necessary to study the records of the colonization of Algeria in anthropometric terms because the classic sources of demographic and economic history are incomplete or less than reliable up to the middle of the twentieth century (Chevalier, 1947). It was not until 1882 that the registry office began to maintain births and deaths records of the native population and only in the early twentieth century that a reliable population census was taken. The Algerian infant-mortality rate is estimated to have been lower than in France, Great Britain, and Scandinavian countries until the beginning of the twentieth century and lower than that of Algeria's European population until the end of the 1940s (Kateb, 2001).

The demographic history of nineteenth-century Algeria is therefore poorly known, even if the demographic extrapolations of Xavier Yacono for the period 1830–1886 have been generally accepted since 1954. According to Yacono (1954) and Ageron (1968), the Algerian population stood at three million in 1830 but then a long decline set in. The low point came with the demographic catastrophe of 1867–1868 after which the trend reversed spectacularly thanks to growth rates that were unequalled until the country's postcolonial period. However, this history is the subject of keen debate between two camps (to simplify the situation; in fact, there are intermediary positions as well, Ageron being an anti-colonialist historian for instance), one arguing for a crisis of the Ancien Régime, the other a colonial crisis.

For the first of these two camps, the key facts are as follows (Figure 1): in 1830 the population numbered three million; between 1830 and 1866 a decline of limited scope occurred; in the demographic catastrophe of 1867–1868 the death toll did not exceed 500,000; the causes of this catastrophe were chiefly climatic (hence "the Ancien Régime crisis")[ii]; and, finally, the period 1872–1886 was marked by an explosion of the Algerian population (H1).

For the second camp (Sari, 1982, Kateb, 2001), in 1830 the population was at least four million;[iii] the demographic decline of the period 1830–1866 was extensive; the death toll of the demographic catastrophe of 1867–1868 came to at least 800,000 and more likely a million; the causes of this catastrophe were largely socioeconomic and colonial, not climatic, like Mike Davis (2001) has demonstrated in the case of the 1876-9 Indian famine (hence "the colonial crisis"); and, finally, during the period 1872–1886 the growth rate of the Algerian population was insignificant (H2).

**Figure 1**




After a presentation of the socio-economic context for those decades for which no reliable quantitative explanatory variables are available (section 3) we will focus on the estimated trend in height of Algeria's colonized population (section 4) and we will compare it with available socioeconomic and demographic indexes (section 5) in order to settle this debate (sections 5 and 6). In other words, we are interested in the *per capita* quantity of available food. Before presenting the results, I shall deal briefly with the question of the representative character of the sources used, since this is a particularly important issue, given the colonial context (section 2): do colonial biases affect the estimation of the height trend (Bodenhorn *et alii* 2013 and 2015)?

## 2. The data: "volunteers" in the French colonial army, and the question of the existence of a colonial bias

To estimate the height of Algerian soldiers, I use the roll-number registers of native volunteers in the infantry (tirailleurs). These data are stored in the French Army's military-history archives in the Château of Vincennes, near Paris. A random selection from all of the roll-number registers available provided the samples in Table 1. Only a part of these selected data was used to estimate heights. The files of volunteers of European origin, duplicate files, and those files that consist of nothing more than re-registrations, devoid of any other information were excluded from these registers of the native regiments --I use the term "natives" (*indigène*), which refers to a specific legal status, for the same reason that one applies the term "slaves" to nineteenth-century black Americans.[iv]

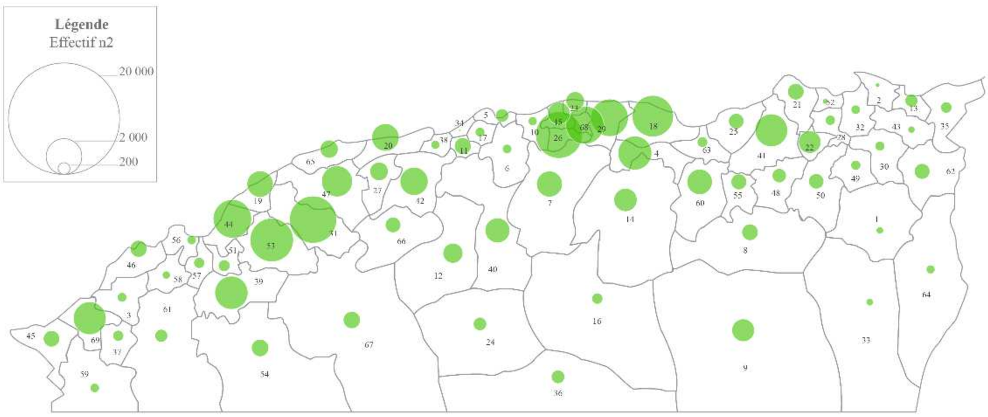
**Table 1**

| series | soldiers | recruitment dates | Total N (estimation) | N (sample) |
|---|---|---|---|---|
| 46 Yc | Tirailleurs | 1855-1909 | 110,731 | 11,992 |

Archives: Service Historique de la Défense, Vincennes.

There is a question mark about just how representative the native volunteer sample is (Map 1).[v] Two general tendencies are expected when looking at the geographical distribution of the declared birthplaces compared to what we know about the distribution of the civil population: a population shift from the more populous east to the west; and a second shift from the coast toward the interior of the country, which was less populated and less affected by the French incursion (Kateb 2001). Indeed, a clear north-to-south shift can be observed (Map 1). Two populated regions are clearly discernable: the Chelif Valley, to the west, where intensive colonization by Europeans drove the Algerians from their lands, forcing them to enlist in the army; and Kabylie, to the east, a mountainous region occupied by small landowners, where, in contrast, colonization was belated and of little importance but where demographic pressure was intense and rural emigration already evident prior to colonization (Yacono, 1955, Mahé, 2001). More precisely these two regions correspond to those mentioned by Cristelow (2012) as the main migration areas of *berrani* (poor rural migrants) in the precolonial and early colonial eras. The low rate (4.8%) of urbanization in the tirailleurs sample is confirmed by the monthly movement of recruitments (graph 1), patterned on the agricultural calendar, and by the occupational profiles of the rural and urban tirailleurs (descriptive statistics of the sample: see table 3).[vi] It is an accurate reflection of the low rate of urbanization among the native civilian population (5–6%). Among tirailleurs, farm-workers were *ceteris paribus* slightly taller than farmers (table 3), although they are usually smaller in other anthropometric studies (for a large sample: Heyberger, 2014). This indicates here the existence of a colonial bias: farmers joined the French army only if they failed to find any other jobs, so only the poorest were volunteers. This confirms, if need be, that the tirailleurs were recruited among the poorest rural populations of Algeria.[vii]

**Map 1: Spatial distribution of the sample (tirailleurs, 1855–1909)**




| | Canton | Eff N1 | Eff N2 |
|---|---|---|---|
| 31 | Inkermann | 388 | 3551 |
| 26 | Dra el Mizan | 295 | 3475 |
| 53 | Relizane | 301 | 3002 |
| 18 | Bougie | 263 | 2720 |
| 44 | Mostaganem | 385 | 2339 |
| 68 | Tizi Ouzou | 212 | 2289 |
| 29 | Fort National | 224 | 2219 |
| 4 | Akbou | 167 | 1810 |
| 39 | Mascara | 230 | 1738 |
| 69 | Tlemcen | 213 | 1697 |
| 41 | Mila | 184 | 1686 |
| 47 | Orléansville | 196 | 1506 |
| 42 | Miliana | 171 | 1237 |
| 20 | Cherchell | 150 | 1181 |
| 19 | Cassaigne | 113 | 1079 |
| 7 | Aumale | 125 | 1044 |
| 60 | Sétif | 112 | 1003 |
| 40 | Médéa | 114 | 960 |
| 14 | Bordj Bou Arrerdj | 115 | 833 |
| 9 | Biskra | 140 | 798 |
| 22 | Constantine | 137 | 785 |
| 15 | Bordj Menaiel | 69 | 773 |
| 12 | Boghari | 54 | 612 |
| 23 | Dellys | 61 | 522 |
| 27 | Duperré | 52 | 517 |
| 65 | Ténès | 64 | 500 |
| 54 | Saïda | 38 | 455 |
| 67 | Tiaret | 56 | 447 |
| 46 | Oran | 55 | 431 |
| 11 | Blida | 62 | 428 |
| 8 | Batna | 57 | 411 |
| 21 | Collo | 57 | 409 |
| 45 | Nemours | 52 | 406 |
| 55 | Saint-Arnaud | 40 | 375 |
| 62 | Souk Ahras | 84 | 373 |
| 66 | Teniet el Haad | 56 | 363 |
| 25 | Djidjelli | 57 | 361 |
| 50 | Ouled Rahmoun | 45 | 352 |
| 48 | Oued Atmenia | 30 | 302 |
| 36 | Laghouat | 32 | 271 |
| 5 | Alger | 51 | 265 |
| 24 | Djelfa | 41 | 265 |
| 13 | Bône | 41 | 246 |
| 61 | Sidi Bel Abbes | 33 | 243 |
| 51 | Perregaux | 28 | 203 |
| 35 | La Calle | 26 | 186 |
| 16 | Bou Saada | 32 | 181 |
| 37 | Lamoricière | 17 | 174 |
| 57 | Saint-Denis-du-Sig | 15 | 174 |
| 63 | Takitount | 18 | 161 |
| 28 | El Arrouch | 16 | 147 |
| 49 | Oued Zenati | 19 | 144 |
| 30 | Guelma | 27 | 138 |
| 17 | Boufarik | 19 | 135 |
| 3 | Aïn Temouchent | 15 | 131 |
| 6 | Arba | 23 | 125 |
| 32 | Jemmapes | 16 | 124 |
| 56 | Saint-Cloud | 11 | 124 |
| 59 | Sebdou | 12 | 123 |
| 10 | Blad Guitoun | 13 | 116 |
| 64 | Tébessa | 27 | 111 |
| 38 | Marengo | 12 | 111 |
| 58 | Sainte-Barbe-du-Tlélat | 13 | 92 |
| 1 | Aïn Beïda | 12 | 74 |
| 33 | Khenchela | 6 | 74 |
| 43 | Mondovi | 6 | 69 |
| 52 | Philippeville | 11 | 43 |
| 2 | Aïn Mokra | 5 | 25 |
| 34 | Koléa | 2 | 4 |
| | cni | 1116 | 5541 |

*cni : canton non identifié*

*N1: effectif extrait*

*N2 : effectif total estimé d'après les pas annuels de sondage*

Does this first colonial bias imply others that could affect the estimation of the height trend?

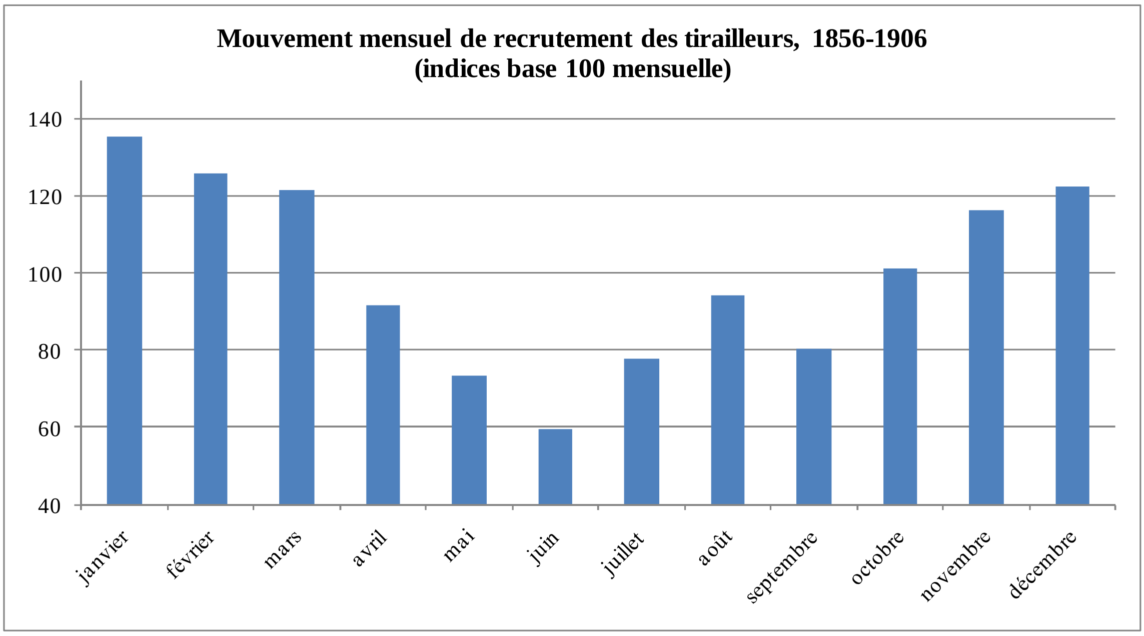
Bodenhorn *et alii* (2013, 2015) have argued that the early-industrial-growth-puzzle observed in the West could be partly due to a statistical artefact caused by biases linked to the market. During hard times (18th-century-England), when job opportunities are scarce, people would tend to join the army, hence taller soldiers and smaller standard deviation of the samples, whereas when instruction becomes more widespread in the society, only the poorest become rank-and-file (19th-century England), hence smaller soldiers and larger standard deviation of the samples. Thus Bodenhorn *et alii* suggest to look at the variations that may occur in the standard deviation and also to control the regressions not only for birth decades, but also for recruitment decades, just like Brennan *et alii* did for India (1994, 1997). For Algeria, one may expect that this kind of bias would result in growing soldiers and shrinking standard deviation, as natives tend to accept or rather to resign themselves to French rule after the first decades of invasion. Nevertheless, the standard deviation remains constant over the whole period or rather is affected by very small variations (Table 2) compared to those quoted by Bodenhorn *et alii*.[viii] Furthermore, compared to the results presented in Table 3, a regression including variables for periods of recruitment defined by socio-economic and military criteria does not change the general increase in height; the increase is smaller, but this phenomenon is due to a statistical artifact, as the population concerned here is very young: one roughly controls twice for the same variable, as birth year + 24 is synonymous with recruitment year - just like in the case of a sample of conscripts, one never controls the regressions for recruitment year-[ix]. Thus, given the unchanged standard deviation over the whole period, it seems more accurate to present the results without dummies for the periods of recruitment, in order not to underestimate the increase in height of each birth decade: a comparison of the trend for adolescents and adults will confirm the pertinence of this strategy.

**Table 2: standard deviation of height by birth decades (1830-1880)**

| Birth decades | N (adults, stature > 157 cm) | SD (cm) | Variation (%, indice 100 in 1860) |
|---|---|---|---|
| 1830 | 598 | 5.14 | -10.5 |
| 1840 | 964 | 5.16 | -10.2 |
| 1850 | 798 | 5.47 | -4.7 |
| 1860 | 699 | 5.74 | |
| 1870 | 503 | 5.53 | -3.8 |
| 1880 | 109 | 5.06 | -11.9 |

157 cm is the highest value for minimum height requirements, observations restricted to adults in order not to artificially increase the values of the SD by the phenomenon of adolescence growth.

**Graph 1: Monthly pattern of recruitments of tirailleurs, 1856–1909**




The height-distribution histograms reveal that truncation points are apparent in the series of minimum height requirements in force in the mother country.[x] A truncated regression is therefore used (for statistical methods see Komlos, 2004).

## 3. The colonial context

From 1830 to the 1880s, Algeria underwent socioeconomic upheavals caused by colonization in four major sectors. First, until 1871 the country was in a semi-permanent state of war. Now, the French were waging war against the civilian population, not an army. Their chief aim was not to conquer the tribes in battle but to starve them into submission by means of raids the purpose of which was the systematic destruction of their means of survival (Julien, 1964, Le Cour Grandmaison, 2005). Sari and Kateb estimate that between 1830 and 1872 war accounted for the death of eight hundred thousand individuals.

Second, the French organized the systematic "dispossession of the fellah" (Sari's expression). The scattering of the tribes, forcing the population to migrate southward, appropriating lands by the enactment of a series of laws all brought about the spoliation of two million hectares, about a quarter of the best agricultural lands of the Tell-Atlas region throughout the nineteenth century (Ruedy, 1992, Kateb, 2001). This was compounded by the spoliation of grazing land and forests --another 5.7 million hectares confiscated-- that were particularly important for the pastoral economy of this country of livestock farmers (Kateb, 2001).

Third, the French maintained the "Arab taxes" inherited from the Ottoman period, at the same time introducing colonial taxes that were shouldered primarily by the natives, prompting a number of historians to conclude that Arabs paid and *colons* spent. The fiscal burden on the Algerian population grew ever heavier (Ageron, 1968, Todd, 2009).

Fourth and last, just like in India in the same period, beginning in the 1850s, the opening of Algeria to the international market and the increasing monetarization of the economy weakened the traditional social structures that had made for solidarity and thereby had, up until that point, compensated for the low productivity of the traditional agricultural system, made it possible to maintain the standard of living, and mitigated agricultural crises (Davis, 2001 for India, Ageron, 1968, Kateb, 2001 for Algeria).

## 4. Results: height stagnation and then height increase of the indigenous population

Statistical analysis of tirailleur heights (Table 3) reveals near-stagnation followed by a (statistically significant) height increase for the 1860s, 1870s, and 1880s birth decades, *ceteris paribus*. As demonstrated by comparing the trends for adults and adolescents, the increase in height after the 1860s onwards was not the consequence of a shift in recruitment from the poorest part of the rural population to a less poor part of the natives, as might have ben expected had the Algerians become resigned to the tightening grip of French rule late in the century.[xi] These two tendencies (stagnation then increase in height) correspond to three distinct economic and demographic phases.

First of all, from 1830 to 1850, one finds that the tirailleurs were affected by a severe colonial crisis, in that they underwent a very slight height increase in a dual context of regression of the available means of subsistence and of demographic decline of the native population[xii]. Even if, as Diana K. Davis (2007) has recently demonstrated, climatic conditions, a factor in the Malthusian crisis, were unfavorable at the time[xiii], the tirailleurs' height stagnation was largely the consequence of a severe colonial crisis, in which, because the death toll due to the war of invasion was offset by the decline (due in part to this war) in agricultural output, their height remained unchanged.[xiv].

**Table 3: Truncated regression, tirailleurs, (birth decades 1830–1880)**

| | coefficient | SE | N |
|---|---|---|---|
| constant | 167.51*** | 0.26 | |
| birthdate | | | |
| known | -0.32 | 0.87 | 48 |
| unknown | reference | | 6,627 |
| birth decade | | | |
| 1830-1839 | -0.59* | 0.3 | 623 |
| 1840-1849 | reference | | 1,509 |
| 1850-1859 | 0.29 | 0.22 | 1,491 |
| 1860-1866 & 1869 | 0.86*** | 0.25 | 1,016 |
| 1867-1868 | 1.47*** | 0.41 | 237 |
| 1870-1879 | 1.92*** | 0.24 | 1,180 |
| 1880-1892 | 2.64*** | 0.31 | 619 |
| age | | | |
| 17 | -3.23*** | 0.54 | 137 |
| 18 | -2.79*** | 0.29 | 553 |
| 19 | -2.77*** | 0.3 | 472 |
| 20 | -1.45*** | 0.24 | 767 |
| 21 | -1.28*** | 0.31 | 433 |
| 22 | -0.79*** | 0.26 | 592 |
| adults | reference | | 3,721 |
| birth milieu | | | |
| urban | -0.43 | 0.34 | 387 |
| rural | reference | | 6,288 |
| birth region | | | |
| Alger | -0.36 | 0.26 | 807 |
| Biskra | -0.4 | 0.41 | 263 |
| Bône | 0.32 | 0.46 | 193 |
| Bougie | -1.55*** | 0.32 | 490 |
| Constantine | -1.36*** | 0.35 | 405 |
| Fort National | -2.05*** | 0.26 | 843 |
| Médéa | -1.27*** | 0.33 | 420 |
| Mostaganem | reference | | 1,411 |

| | | | |
|---|---|---|---|
| Oran | -0.45 | 0.35 | 378 |
| Sétif | -1.24*** | 0.34 | 399 |
| uc 91 | -1.2*** | 0.35 | 417 |
| uc 92 | -0.43 | 0.52 | 141 |
| uc 93 | -1.01*** | 0.34 | 508 |
| spatial mobility birth-recruitment | | | |
| non | reference | | 3,778 |
| yes | -0.27* | 0.16 | 2,897 |
| occupation | | | |
| farmer | reference | | 2,082 |
| farm-worker | 0.25 | 0.2 | 1,473 |
| former soldier | -0.09 | 0.28 | 636 |
| unknown | 0.14 | 0.21 | 1,712 |
| without | -0.78* | 0.34 | 386 |
| misc. | -0.3 | 0.35 | 386 |
| smallpox | | | |
| yes | 0.14 | 0.32 | 362 |
| no | reference | | 6,313 |
| total | | | 6,675 |

uc: unidentified canton (district) of birth. 91: department of Algiers, 92: department of Oran, 93: department of Constantine.

***: significant at the 0,1%, **: 1%, *: 10% level.

The difficulties culminated in the 1860s: the decade of the "demographic catastrophe" (1867–68), in which between half a million and a million Algerians died of hunger (because of an invasion of locusts, a drought, and the opening of the market) and epidemics, whereas height increased. In fact, between the 1850s and 1860s the height of French Algerian conscripts (European *colons* or settlers) did not increase but instead stagnated.[xv] The conjunction during the 1860s of a height increase and a demographic decline could therefore count as a major colonial crisis, since it concerned native Algerians only and not *colons*. At this point the death toll was so high that the *per capita* food supply among the native population increased and/or there was a selective effect: only the strongest, the richest, who were also the tallest, survived: a situation unique in the annals of anthropometric history, even compared to what we know or rather assume about the Irish Famine or the Indian famine of 1876-1879.[xvi] The demographic crisis struck Morocco and Tunisia too, but less dramatically than in Algeria - which is taken as evidence of its colonial character (Sari, 1982).

## 5. Height trend of the tirailleurs and exogenous variables: climate and gross nutrition

Finally, the decades of the 1870s and 1880s cause debate. For some historians, such as Ageron, the difficulties increased: the tax burden on the natives doubled, the rate of spoliation of their land in the 1880s was higher than ever, and famines occurred sporadically. Most importantly, drawing on the official results of censuses (H1) as well as the hypothesis of constant output and a constant sown surface area, and looking only at the census years, Ageron estimates that the *per capita* grain production fell by 31 percent between 1876 and 1886, the year of what was unanimously rated to be the first reliable census. Furthermore, if one looks at the annual variations of these figures (1851–1893, not presented here), translated into calories available *per capita*,[xvii] one obtains unbelievable results before 1859: the daily calories available were below the minimum of the 1867 famine (985 calories).[xviii] The same can be said for the production/available calories of European settlers in Algeria, although here censuses are reliable: very low values are observed between 1851 and 1858.[xix] It seems, then, that agricultural surveys, based on fiscal activity, were unreliable before 1859: crops were positively correlated with rainfall over the 1859–91 period, but far less so for the 1854–1891 period.[xx] Moreover, the fact that the correlations are stronger for Europeans than natives indicates that production statistics are more reliable for Europeans, since the crops of natives were more dependent on rainfall and other climatic conditions than those of Europeans (Mollard, 1950): we would have expected stronger correlations for natives.

In spite of these imperfections of the agricultural surveys, the demographic hypothesis of Ageron and Yacono (H1) was tested using correlations between stature and explanatory variables including nutritional supplies (Table 4). Protein availabilities are considered in order to test Baten's "milk hypothesis", *i.e.* the idea that from a historical perspective dairy products are very important for growth of the human body (Baten, 1999a, 1999b, Baten, 2009, Heyberger, 2014).[xxi] Nevertheless, it should be noticed that livestock are considered as the least reliable agricultural series (Ageron 1968, Ruedy 1992), as confirmed by the absence of correlation between the annual increase in livestock and rainfall.[xxii] Finally, one also considers the possible influence of wheat prices on stature, since according to some historians (Nouschi 1960, Ageron 1968) during the opening of the Algerian market to international trade (1851–

1891) the indigenous people supposedly behaved more like sellers than self-sufficient consumers.[xxiii] Nevertheless, the results in Table 4 show that the indigenous people actually behaved rather like consumers (negative correlation), just like in France (Komlos, 2003, Heyberger, 2003), even if here the correlation is weak, statistically not significant and economically not credible: a (huge) fall of 12,66 francs in the price of wheat (francs per hectoliter) is supposedly correlated with a height increase of (only) 1 cm.

**Table 4: Tirailleur stature by birth cohorts (1863–1886)[xxiv] and explanatory variables**

| Explanatory variables | unit | mean | SD | constant | coefficient | P | $R^2$ |
|---|---|---|---|---|---|---|---|
| precipitation | mm/year | 725 | 136 | 164.29 | 0.006 | 0.09 | 0.46 |
| cereals H1 | calories/inhab./day. | 2,380 | 721 | 168.11 | 0.000 | 0.93 | 0.00 |
| cereals H2 | calories/inhab./day. | 1,845 | 585 | 166.08 | 0.001 | 0.07 | 0.50 |
| proteins H1 | g/inhab./day. | 18.5 | 3.9 | 168.42 | -0.004 | 0.97 | 0.00 |
| proteins H2 | g/inhab./day. | 14.4 | 3.9 | 166.76 | 0.11 | 0.17 | 0.34 |
| price of wheat | francs/Hl | 21.62 | 3.00 | 170.07 | -0.079 | 0.56 | 0.07 |

Table 4 shows there is no correlation between food intake and stature if one considers the population numbers given by Yacono (1954) and the official censuses (H1) to be reliable. On the contrary, correlations do exist if one follows the hypothesis of Sari and Kateb (H2). Nevertheless, although the correlation is economically credible in the case of cereals, it is not so for protein.[xxv] Furthermore this last correlation is not statistically significant: this result confirms that the livestock series are unreliable. Finally, annual precipitation, which should be correlated with both actual and unobserved dairy production and --actual and unobserved-- cereal production, is also positively correlated with stature: an increase of 167 mm/year (22% of the mean annual value, or 117% of the standard deviation for the 1838–1891 period) is associated with a 1 cm increase in height.

## 6. Consequence: height trend of the tirailleurs, McKeown's hypothesis and questioning the Ancien Régime vision of demographic history

Hence it seems that the only explanation for the height increase of the tirailleurs is an increase in food available *per capita*, in the context of demographic stagnation and increased precipitation between

1872 and 1886 (H2),[xxvi] unless one considers that the correlations are statistical artifacts and that actually the height increase was caused, again in a context of demographic stagnation, by an improvement in the conditions --rather than the standards-- of living, according to the theory of McKeown (1976).

Indeed, for some historians, such as Yacono, the situation between the 1870s and the 1880s improved --at least for the settlers-- thanks to the campaign the French waged against malaria (Yacono, 1955, Baroli, 1976, Curtin, 1989, Ruedy, 1992), especially in the Chélif Valley. In the nineteenth century, malaria was one of the leading causes --and maybe the primary cause-- of death among settlers and, it may be assumed, natives (Bonnafont, 1839, Bertherand, 1855, Ageron 1968, Curtin, 1989, Moulin, 1996). As demonstrated by the exploration of untapped Algerian data for the 1910s birth cohorts, there was a negative influence of malaria on stature (regression not presented here), since human bodies expend nutrients useful for human growth to fight against diseases.[xxvii] In the Algerian context of the end of the nineteenth century, the campaign waged against malaria should have been reflected by a height increase, at least for settlers, but instead height stagnated.[xxviii] Hence the hypothesis that the height increase of the natives could be explained by an improved epidemiological context can be dismissed: it is unlikely that hygienic and prophylactic measures made for settlers, but without any positive impact for them, could have had any positive impact on the trend of natives. One can draw a parallel with the United States during the nineteenth century; the divergence between the height trends of the free and slave populations has been cited by those who find a nutritional explanation for the height decline, whereas their opponents argue that the cause was primarily epidemiological, thereby implying that the illness factor affected the entire population, which seems dubious (Maloney & Carson, 2008).

The other chronic diseases that one observes in North Africa –and India- at that time and that kill many inhabitants are also unlikely to explain the increase in height for the 1860s onwards because of an unchanged epidemiological environment, with the exception of cachexy[xxix]. Last but not least, the coefficient associated with smallpox, another chronic disease of nineteenth-century-North-Africa, indicates a very small and positive (but statistically not significant) effect of this disease on height (Table 3). This might be thought an unexpected result, since smallpox is usually associated with smaller bodies (Steckel, 2009 for a synthesis) but that could also confirm Oxley's (2003 and 2006) results, here in the context of a very rural sample: in England, it seems that the smallpox penalty was linked to the urban penalty. This result implies that a decreasing rate of this disease among the native population at the end of the century[xxx] is unlikely to translate into an increase in height.

Furthermore, regression (Table 3) show that, just like in Egypt (Stegl and Baten, 2009), an urban penalty existed for the natives of the traditional, rural countries of the nineteenth-century East, but the coefficients are here very small and not statistically significant,[xxxi] suggesting that the phenomenon of urban penalty caused by the epidemiological context of the cities was a phenomenon typical of the industrial revolution occurring at that time in the West (Floud, Wachter and Gregory, 1990, Riley, 1994, Ó'Gráda, 1996, A'Hearn, 2003, Cranfield and Inwood, 2007, Cinnirella, 2008a and b, Heyberger, 2014).

The sample also shows something like spatial uniformity in anthropometric terms, with the exception of Kabylia (Fort National- l'Arbaa Naït Irathen and Bougie-Bejaïa): this result may be explained by the high rural density of Kabylia, which could imply here again a bad epidemiological context. Above all, the anthropometric index confirms here the legendary poverty of this region of smallholders and migrants (Mahé, 2001). Finally, the small --and not significant-- anthropometric penalty associated with the mobility of soldiers is a surprising result (Table 3), since usually migration is associated with an anthropometric bonus (Danubio, Amicone and Vargiu, 2005, Mironov and A'Hearn, 2008, Boëtsch, Brus and Ancel, 2009, synthesis in Steckel, 2009). Nevertheless, mobility between birthplace and place of recruitment is not synonymous with migration, especially in a colonial context. Furthermore, this penalty could be interpreted as a sign of poverty: only the poorest moved to join the colonial army of the French invaders.

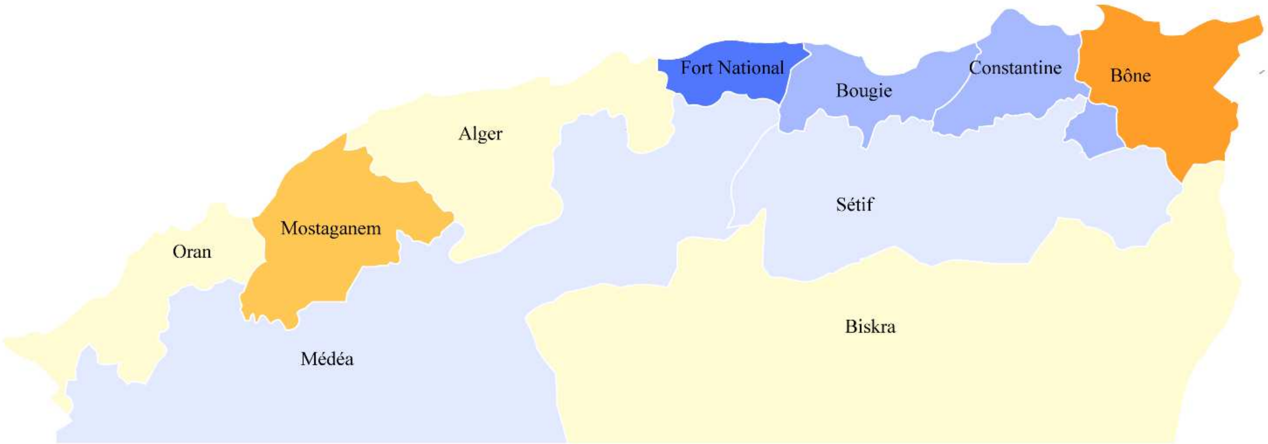
To sum up, if, like Kateb and Sari, one admits that between 1872 and 1886 there is no record of demographic growth but simply a series of increasingly reliable censuses, one has the most coherent picture, combining a noticeable height increase, demographic stagnation, increase in *per capita* production, and an unchanged epidemiological context -- at least for natives. There is a final explanatory factor of the height increase that cannot be quantified; according to Kateb, the probable shift after 1870 into the first phase of the demographic transition is explained by a group of factors identified by McKeown as changes in living conditions, and more specifically the end of the permanent state of war (McKeown, 1976, Kateb, 2001). As already mentioned, the war was waged against the civilian native population, mainly by means of starvation. Nevertheless, the end of that war is mentioned by the famous demographer Demontès (1906) as an important cause of the fall in the mortality rate for European settlers after 1872. Thus it must have had an even greater positive impact on the mortality rate and the living conditions of the natives.

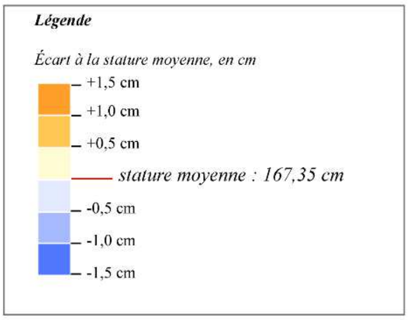
## 7. Conclusion

Our scenario confirms Sari's work, for it implies demographic stagnation between 1872 and 1886, thereby supporting the idea that the estimated bottom line of the size of the Algerian population in 1830 should be revised upward: if the native population numbered about 3.2 million in 1886 and 1872 (Figure 1, H2) then, even by the most conservative estimates of population losses both for the demographic disaster of 1867–68 and for the war of invasion (Lefeuvre, 2006, Pervillé, 2012)[xxxii] the Algerian population must have numbered at least 4.2 million in 1830 instead of 3 million according to Yacono, and even about 5.2 million if one follows the estimates of losses by Sari and Kateb.

The nineteenth-century colonization of Algeria thus appears, in the light shed by the anthropometric index, to have been a devastating experience for the native population, since the population level in 1830 did not recover before the early twentieth century (at least: 1906 census). The Algerian experience also emphasizes the need to take into consideration both the trend of stature and the demographic trend when dealing with anthropometric studies with Malthusian or colonial crises. During the first decades of colonization (1830–1860), the equilibrium between a declining population and dwindling means of subsistence translated into a height stagnation or a very slight height increase, emphasizing the idea of a colonial crisis. This crisis culminated during the demographic disaster of 1867–68, when the population lost at least 500,000 inhabitants and height increased. Nevertheless, our results also confirm in part the Ancien Régime vision of demographic and economic history, since even at the end of the century, in a context of demographic stagnation, climatic conditions seem to have been more important in explaining the change in living standards than the forced opening of Algeria to the international market.

**Appendix : Regions of control, regression of table 3 (tirailleurs) and anthropometric map of Algeria (birth cohorts 1830–1892)**




| Région | Stature moyenne adulte (cm) | Écart à la moyenne (cm) |
|---|---|---|
| Fort National | 166,12 | -1,23 |
| Bougie | 166,62 | -0,73 |
| Constantine | 166,81 | -0,54 |
| Médéa | 166,90 | -0,45 |
| Sétif | 166,93 | -0,42 |
| Oran | 167,72 | 0,37 |
| Biskra | 167,77 | 0,42 |
| Alger | 167,81 | 0,46 |
| Mostaganem | 168,17 | 0,82 |
| Bône | 168,49 | 1,14 |
| Stature moyenne de l'ensemble (en cm) | 167,35 | |

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[i] Historians estimating that the population in 1830 numbered three million, regardless of the other key facts of the "Ancien Régime crisis": Prenant, 1960, Nouschi 1961, Julien 1964, Amin, 1966, Ageron, 1968, Valensi, 1969, Perkins, 1981, Bennoune, 1990, Ruedy, 1992, McGowan, 1994, Le Cour Grandmaison, 2005, Lefeuvre, 2006, Davis, 2007, Gallois, 2008.

[ii] With this estimation, this would imply that 19% of the population died during the famine, compared to 2.8-4.7% for the 1876-1879 Indian famine studied by Mike Davis (2001) or to the greatest famine of the "Grand Siècle" in France (1693-1694: between 10 and 15%). According to H2 (colonial crisis), this figure is even more impressive (24%).

[iii] Historians estimating that the population in 1830 numbered 4.2 million or at least that the population stood at a high value after the French invasion, implying a revision of the value for 1830: Saidouni, 2001, Brower, 2009, Manning, 2010, Sessions, 2011.

[iv] This explains why the numbers are not the same in Table 1 and the following tables or map. For the question about this vocabulary: Urban (2010).

[v] Legend: N1: N randomly selected, N2: total N estimated according to N1 and sampling rates. Between cantons (districts) N1/N2 is not a constant, since a given year of recruitment could be found in several registers, but does not necessarily concern the same districts, whereas sampling rates vary over years of recruitment. So that the differences of sampling rates between districts do not disturb the geographical analysis, only N2 are shown on map 1. Place of birth is generally given by fractions of tribes, which represent the equivalent of a village population, for a population which was largely (semi)nomadic (Ruedy, 1992: 45% of nomads in 1830, census of 1844–45 --quoted by Kateb, 2001--: two thirds of the tribes are (semi)nomadic). A canton (district) covers about the area of a French department or a US county. Map 1 is after Accardo, 1879 and Gouvernement Général de l'Algérie, 1875.

[vi] Occupation of tirailleurs by place of birth (recruitment years: 1856–1909)

| occupation | urban | rural |
|---|---|---|
| farmers | 7.6 | 33.5 |
| farm-workers | 29.3 | 21.1 |
| former soldiers | 11.5 | 8.1 |
| without | 3.9 | 7.5 |
| other | 23.6 | 4.1 |
| unknown | 24.1 | 25.7 |

Note : the high value for farm-workers in cities is explained by the definition of that occupation: all day-laborers are included in farm-workers, but some of them actually worked in cities and crafts. Nevertheless, including all the day-laborers who declared they were born in cities in the "other occupations" category is even more problematic.

[vii] For the same kind of colonial bias shown by anthropometric indicators, see Brennan *et al.*, 1997. For the sociology and geographical patterns of the recruitment in the early twentieth century, see Recham, 1996 and Meynier, 1982.

[viii] Based on the English sample (Floud *et alii*, 1990): using the unbiased SD recommended by Komlos (6.9 cm) as reference, the observed SD fluctuate wildly (50% between the smallest and the highest values), whereas the changes are of little importance in the Algerian sample (9.8%, very similar to the changes observed in the population of European conscripts of Algeria for the same period, but here no market effect is expected -6.1%, sample not used in the present paper). Furthemore, Bozzoli *et alii* (2009) suggest to use 6.0 instead of 6.9 as an unbiased reference for SD: the variations in SD for the Algerian sample would be then even smaller.

[ix] Four recruitment periods are defined by the observed variations in rainfalls (kindly made available by Diana K. Davis: rainy periods may imply better crops and then that less people wish to join the colonial army and *vice versa*), except a recruitment variable created for the 1867-68 famine and another created for the 1870-71 Franco-Prussian war (this last is affected by a coefficient of -1cm, which tends to prove that tirailleurs had the choice to join or not the French army, but contrary to what was expected, no anthropometric bonus for those who join the army during the 1867-1868 famine). Between model of Table 3 and the model including these variables of recruitment, the increase in height drops by 1.4 cm. The soldiers are 24 years old (mean), the SD is 5 years, the distribution of age is roughly normal and even more concentrated than expected according to the Gaussian distribution: 73% of the sample is between plus or minus 1 SD of the mean (against 68.2% according to Gaussian distribution).

[x] 1856–67: 156 cm; 1868–71: 155 cm; 1872–1901: 154 cm, no minimum height requirement after 1901.

[xi] Last nation-wide native rebellion before the war of Independence (1954-62): El Mokrani, 1871. The richer individuals are,

the faster they grow and the smaller the difference between adolescents and adults (Bogin, 1999, Vignerová, Brabec, Bláha, 2006, Komlos, 2008). A shift in the recruitment toward richer individuals should have been reflected by a height increase and a decrease in the height difference between adults and adolescents. This is not the case (Table below). On the contrary, the height trend and the change in adult-adolescent differences indicate improvements in the standard of living among a population of poor farmers: combination of height increase and increase in the difference between adolescents and adults.
For the same birth cohorts of a poor population, those measured after the end of the growth spurt of adolescence benefit from a nutritional experience that they do not share with those measured before this growth (Komlos 2003). So the variations in stature between adolescents (17–22 years old) and adults (23 years old and more) for the same birth cohorts are an indicator of the living conditions for the period between adolescence and adulthood. The worse the conditions during this period, the smaller the growth spurt and so the difference between adolescents and adults.

Evolution of adult-adolescent differences in stature for the same birth cohorts (1840–1879)
Source: regressions not presented here

| **birth years** | **difference (cm)** | **extreme dates of measurement of adolescents** |
|---|---|---|
| 1840-1849 | 1.35 | 1857-1871 |
| 1850-1859 | 1.92 | 1867-1881 |
| 1860-1866 and 1869 | 1.88 | 1877-1891 |
| 1867-1868 | 2.14 | 1884-1890 |
| 1870-1879 | 1.51 | 1887-1901 |

The smallest difference is observed for those born during the most active years of the war of invasion (the 1840s, when there were more soldiers --100,000-- than settlers in Algeria) who also experienced poor living conditions during adolescence (again 100,000 soldiers during the 1860s, drought, invasion of locusts, famine, epidemics, etc.) The biggest difference is observed for those born between 1850 and 1869, during very hard times, but who benefited from better living conditions during the period between adolescence and adulthood (1871–1891: increased rainfall and crops, peacetime, see *infra*). Finally, those born in the 1870s experienced better living conditions during infancy, but not so much during adolescence (decreasing rainfall, among other things).

[xii] However, the coefficients associated with these birth decades are not all significant.

[xiii] There is even a negative correlation between height (means over three years of birth) and rainfall (kindly made available by Diana K. Davis) for the 1840–1842 to 1861–1863 birth cohorts (N = 8, $R^2 = 0.51$). This means that there are more influential factors than rainfall (i.e. war and its consequences, loss of inhabitants, then increase in *per capita* food supplies) explaining the increase in height.

[xiv] The hypothesis of an equilibrium between decreasing food supply and decreasing population for the 1830–1866 period was already made by Boyer at the end of the French era (1960), but there to defend the record of French colonization: needless to say that the mechanisms mentioned by Boyer referred to a Malthusian (Ancien Régime) crisis rather than a colonial crisis.

[xv] Regressions not presented here, sources: Centre des Archives d'Outre-Mer, Aix-en-Provence, registres matricules, random sample, N = 3,619 individual files, men born between 1850 and 1886. With time-variables more finely defined, one can even observe a slight fall in height among the European population during the 1867–68 demographic disaster: the famine did not spare the *colons*, but the impact of the demographic disaster was less dramatic for settlers than natives.

[xvi] On the question of selective effect, see controversial arguments in Alter, 2004 and Moradi, 2010. For the Chinese Great Famine of 1959-1961, Tue GØrgens *et alii* (2012) conclude that the selective effect (mortality) compensate for the nutritional effect (stunting). There is no direct evidence of the anthropometric impact of the Irish Famine. Nevertheless, Barry Bogin supposes that stature was likely to fall during and just after the famine (Bogin, 1999). Brennan *et alii* (1994 and 1997) do not address specifically the question of the 1876-1879 Indian famine, but their regressions seem to prove that there was no anthropometric effect for the North of India, whereas a clear penalty appears for the South.

[xvii] Hard and soft wheat and barley, which represented 92.6% of the sown surfaces (sources: *TEF* and *SGA,* see references). Considering the approximations of the productions concerning those main cereals, it is not necessary to take into consideration the production of cereals of secondary importance such as sorghum (*bechna*). Supplies: net production from sowing, losses for storage and import-export, even if trade did not affect the trend of available calories.

[xviii] Even after 1859, some values are unreliable, erring on the high side, for instance for 1863 and 1875 (3,535 and 3,768 calories).

[xix] *TEF* and *SGA* provide productions by ethnicities/status (Europeans/indigenous). Here again, even after 1859, one can observe very high values for some years: between 1872 and 1884, seven years for which *per capita* supplies exceeded 4,000 calories.

[xx] Correlations between crops and rainfall (1854–1891)
Source: *TEF* and *SGA*

| | 1854-1891 | | 1859-1891 | |
|---|---|---|---|---|
| | natives | Europeans | natives | Europeans |
| barley | 0.07 | 0.12 | 0.19 | 0.21 |

| | | | | |
|---|---|---|---|---|
| hard wheat | 0.05 | 0.10 | 0.09 | 0.20 |
| soft wheat | 0.01 | 0.12 | 0.29 | 0.23 |

At the local level, the estimations of crops -and cattle- are made by the officers of the *bureaux arabes*, created in the 1840s (Establet, 1991, Frémeaux, 1993), with the help of native notables hired by the French. Thus the very low values of the 1850s are explained by the long time it take to organize that administrative framework and to hire notables (some of them were already hired to do the same job under the Turkish rule) See also Todd, 2009 for the explanation at the national level of the under-estimation of the first decade.

[xxi] Table 4, protein availabilities from cow, ewe and goat milk. As for cereals, livestock and estimated *per capita* daily milk production are presented in *TEF* and *SGA* by ethnicities/status.

[xxii] Annual growth of livestock and rainfall, indigenous (1868–1891) and Europeans settlers (1863–1891)
Source: *TEF*, *SGA* and Diana K. Davis

| | indigenous | Europeans |
|---|---|---|
| bovines | 0.05 | 0.01 |
| sheep | 0.01 | 0.08 |

It seems dubious that other factors such as epizootics could explain the absence of correlation between growth of livestock and precipitation.

[xxiii] No complete series of wheat prices for Algiers, wheat prices in Marseille in Drame, Gonfalone and Miller, 1991. As, on the one hand, the year of birth is not precisely known because of the phenomenon of age heaping and as, on the other hand, socio-economic factors are very important in determining final height especially during the period between birth and the age of three (Bogin, 1999), for a given year of birth one considers in Table 4 the mean of the explanatory variables during the three first years of life (for an application of this method in the French case, Heyberger, 2003). Furthermore, considering the small number of individual data by single year, birth years are pooled by three.

[xxiv] N = 7 cohorts: 1863–65, 1866–68, 1869–70, 1871–73, 1874–76, 1881–83, 1884–86. In order to compare *ceteris paribus* the influence of the different explanatory variables, only those years for which we have at our disposal the values for all the variables are considered. Mean and SD of the explanatory variables are computed from annual values.

[xxv] H2: an increase of 1 cm is associated with a daily calorie increase of 1,000 cal. In the case of the mother country, an increase of 1,250 to 5,000 cal. is needed to observe a 1 cm increase in height (depending on whether one considers availabilities computed from farm-workers budgets or mean supplies of the whole population, depending also on whether one considers individual or pooled data: Heyberger, 2009).

[xxvi] The trend of the precipitation series provided by Davis is in line with the trend observed for Africa (Spinage, 2012).

[xxvii] Sources: Centre des Archives du Personnel Militaire, (CAPM), Pau, registres médicaux d'incorporation, N = 1,339, extreme birth years 1902–1919, mean age: 21.7.

[xxviii] Regression not presented here, see note xv for sources.

[xxix] Respiratory illnesses and gastro-intestinal diseases (for North Africa: Panzak, 1993, for India: Klein, 1989). There is an improvement of the sewing-system under French rule at the end of the 19th century, which could have a positive impact on the decline of gastro-intestinal diseases, but given the very small share of natives living in the cities, this phenomenon has no impact on the height of the tirailleurs, whereas the anthropometric impact of respiratory illnesses, observed thanks to the medical files of those native conscripts of the 1910 birth decade already mentioned (regression not presented here) is rather small. Furthermore, there is no reason why to expect a decline in the prevalence of respiratory illnesses at the end of the 19th century. Cachexy is linked to under-nutrition, then its decrease is all the more possible at the end of the 19th century given the socio-economic context, but its effect is already captured by the nutritional variables.

[xxx] which could have been caused by the medical action of the French in Algeria.

[xxxi] For the tirailleurs, the fact that there is a slight and statistically not significant penalty for those who knew their exact birthdate (Table 3) could also been interpreted as an indication of the existence of a small urban penalty, since the registry office began to maintain birth records for the very small proportion of the native population who lived in cities from 1830 onwards (Sari, 1982, Kateb, 2001).

[xxxii] Demographic disaster: 500,000 deaths. In his estimate of the losses during the war of invasion, Pervillé stops in 1850 (500,000 deaths). At least, one should add the deaths of the invasion of Kabylie (1857) and the Ouled Sidi Cheikh (1864) and Mokrani (1871) rebellions. For another recent upward estimation of the Algerian population, but using very different hypotheses (continental approach, then no reference to the demographic disaster of 1867–68), see Manning, 2010.