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The Last Century of Malaria in Ferrara: from the Unification to the Boom Years

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ABSTRACT

The Last Century of Malaria in Ferrara

The Official Authority recognized that Ferrara was completely free from malaria on March 8, 1966. The history of the last century of malaria in Ferrara, drawing on the reports of the doctors involved in the fight against malaria, retraces the three antimalarial strategies that have followed one another, interspersed with the two World Wars. The changes in the ecological context extremely favorable to malaria, present in a large part of the province of Ferrara, leads the historical reconstruction.

Keywords: Malaria - Remediation program - Ecological contest - Poverty

Introduction

"The History of Malaria is a True Scientific Novel" (Bastianelli G., 1941[1])

On March 8, 1966, the President of the Italian Republic officially declared the disappearance of malaria from Ferrara. For the last century of malaria in Ferrara, data and documents allow a quantitative representation of the disease and a description of the struggles to eradicate it as well as its heavy impact on the conditions of the working classes.

Malaria had such an impact that the Nitti's statement applies also to the ferrarese peasants: "Malaria causes misery; but in turn it is misery that makes malaria more terrible"[2]. An episode demonstrates the validity of the reference to southern peasants: "In 1951 Vancini edited, in Rome, a feature film on the Po Delta: the editors believed that the images had been shot in Southern Italy"[3].

This contribution[4] presents the historical series of mortality from malaria in Ferrara, compared with the national data, and a first survey of all structured interventions of the anti-malarial struggle in the Ferrara area.

A reconstruction of the ecological context[5] that made this territory (with entire upper Adriatic coast) an epidemiological unicum in Northern Italy[6] accompanied the survey.

The description of the ecological context traces the factors of transmission of malaria according to the Russell formula[7] and the three parameters of malaria risk[8]: receptivity (presence, density and biological characteristics of anopheles), infectivity (ability of a species to become infected and to transmit malaria), and vulnerability (number of gametocyte carriers in circulation). The overcoming of the particular ecological context only allowed the elimination of malarial parasites, achieved with DDT[9].

The ecological context of Ferrara in the second half of the nineteenth century (1861-1898)

Among the health problems that afflicted Italy after the Unification there was a resurgence of malaria, driven by the capitalist evolution following the unification and the consequent environmental[10] and demographic changes. Only twenty years later, the Parliament investigation about the railways will be detected this serious problem, excellently summarized by Senator Luigi Torelli[11].

The malaria resurgence also manifested itself in the Ferrara area, where in the last two decades of the nineteenth century the malarial endemic [a situation characterized by the constant appearance of cases for several years through natural transmission on site] worsened becoming "meso-endemic with hyper-endemic areas", driven by favorable environmental and social conditions.

The Ferrara area had very favorable environmental conditions both for the reproduction of vectors, due to the extensive presence of water collections (in 1865 the province of Ferrara had 123,000 marshy hectares, out of 263,500 hectares[12]), and for the reproduction of Plasmodia, due to the climatic conditions of atmospheric temperature and humidity, resulting in a high receptivity.

About 60 species of anopheles, with very different levels of infectivity, transmit malaria, with a very variable presence from area to area. *An. sacharovi* was the most common species in the Ferrara area[13], characterized by maximum receptivity - due to the Ferrara environment of the time that allowed larval development (small collections of fresh water with aquatic vegetation, sunny places with high ambient temperatures (22°-23°C) and high atmospheric humidity). This species was also highly infectious, being a strongly anthropophilic and endophilic (it remains inside the houses after the blood meal). The flexibility in the choice of its habitats - withstands stagnant waters up to 38-40°C and weak currents, withstands brackish water well, adapts as an adult to all sheltered environments - further increased its infectivity[14].

The capitalist impetus following the unification hit the Province of Ferrara with extensive hydraulic reclamation interventions that led it to be the Holland of Italy. Isenburg effectively summarizes the story of the first post-unification reclamations: "Between 1872 and 1880 a series of entrepreneurs - especially banks - invested large capital in the province of Ferrara to reclaim the marshy lands to the east of the city. Since it is a speculation - an undertaking carried out exclusively to make high capital yield quickly, making the most of public subsidies - the works are carried out without hydraulic or agronomic expertise. The results are therefore particularly bad; however, the investment of capital causes a revolution in the countryside: many workers is required to carry out the hydraulic reclamation. Masses of agricultural workers leave the land and are concentrated in the lower Ferrara area, employed by new entrepreneurs: they become wage earners, diggers and day labourers (scarriolanti) and they rapidly suffer a deterioration in their social position. Around 1880, the hydraulic reclamations ended but the previous equilibrium is now broken: the laborers remain to build an army of manpower at the disposal of the capitalist (company or private)"[15].

In this period, about 88,000 hectares were reclaimed with major agricultural transformations that resulted in a sum of several factors. The reclamation failed to eliminate outbreaks of multiplication of mosquitoes: "the drying up of the land was not followed by a rational amendment of it, so that many lands where wheat is harvested today are more malarious than when [they were] covered by water most of the year" (Argenta Health Officer;1899[16]). The economic development was far from capitalist efficiency (lack of agricultural structure of large companies, very low agricultural production, bankruptcies)[17]. The resident population increased around the reclamations (between 1881 and 1901 in the Comacchio district the population increased by 15% while the provincial average increase was 9%, however higher than the national average)[18]. There was high seasonal unemployment with consequent primitive conditions of life of the laborers.

Adriano Prosperi summarizes the condition of peasants in the nineteenth century with the triad "unhealthy housing, poor nutrition, excess work[19]": the inhabitants in the villages surrounding the reclamation were very poor families, "housed in clay hous-

es", with a caloric and nutritional undernourishment because of low-income levels. "Being in a municipality with malaria implies an increase in the Gini index of 0.22, which corresponds to about one-third of the mean land inequality in the sample"[20]. The Jacini investigation put the emphasis on overcrowding: "The agglomeration of laborers families is sometimes frightening. In a few small houses there are perhaps 100 families piled up[21]". Bertani investigated the hygienic conditions of land workers, drawing the conclusion that "in rural houses all the conditions for the greater spread of infectious diseases concur"[22]. The anti-malarial station of Ferrara describes the living conditions of laborers in Argenta as follows: "the families of laborers are about half of the rural population and constitute the most disadvantaged class and most pestered by disease. Often 8-9 people sleep in the same room. The diet is totally maidic for six months, with the addition of wheat mixed with corn in the other months"[23].

All these conditions facilitated the outbreak, persistence and spread of malaria, as recalled in 1910 by the Badaloni Report: "The Tuscan proverb "malaria is in the pot" and the Venetian proverb "chi xe mal nutrio, la freve ghe tien drio" (malnourishment and fever go together) have a great foundation of truth. The affluent classes - even in the areas most hit by malaria - are much less exposed to the infection than the working classes; but in the sense that they are more resistant to the infection due to the conditions in which they live"[24].

The presence of gametocyte carriers makes a territory vulnerable: the fragmentation of statistics on malaria in the first post-unification decades makes it difficult to estimate the vulnerability (number of subjects with circulating gametocytes present in the territory) for the 19th century.

In 1849, the head of the Comacchio hospital described the city as hypoendemic: "Pernicious in Comacchio are very rare"[25]. In 1859, the Prof. Luigi Bosi[26] described Ferrara as hypoendemic too: "The city of Ferrara and some localities in the Ferrara area have only a very slight degree of marsh endemic, with periodic fevers between August and December, which mainly affect the humbler classes"[27].

A first quantitative data derives from the "Geografia nosologica d'Italia"[28], where Giuseppe Sormani[29] provides statistics of the causes of dispensations from military service, including "chronic diseases of the digestive organs". It is plausible that this category indicated malarial splenomegaly, as claimed by Sormani himself: "I have all reasons to believe, that under this title we understand especially spleen hypertrophy, a consequence of malaria cachexia". The territorial distribution of the indicator, cumulative for the years 1863-1876, is highly uneven: the recruits of the Comacchio district have a value (0.9%) double the national average (0.4%), three times the provincial average (0.3%), four times the value of the recruits in the Ferrara district (0.2%).

The clear correspondence between the map of the prevalence of dispensations for "chronic diseases of the digestive organs", prepared by Sormani, and the Malaria Map of Italy[30], by Torelli, should be underlined.

The "Malaria map of Italy" constitutes the first comprehensive - however qualitative - information on a national level of malarial morbidity and shows that the areas of "very serious" malaria in the North are limited to a coastal area extended from Friuli to Ferrara, corresponding to the habitat of *An. Sacharovi,* as noted by Missiroli's researches fifty years later[31].

Hospital admissions for malaria are not very informative as "a hospital cannot give an exact picture of the malaria epidemic, because mild cases and those who are treated outside are not included, as well as those who move away from an unhealthy place after seasonal work". Therefore, the data on admissions at the S. Anna Hospital in Ferrara give some informations, limited to the urban center. In the last thirty years of the nineteenth century, about 7% of hospitalizations in the hospital in the county town were due to malaria (Tab.1). A hint of improvement can be glimpsed in 1901 (6% of hospitalizations for malaria). For a comparison (purely indicative), it is considered that hospitalizations for malaria in Rome constituted 25% of hospitalizations[32].

Tab. 1. Hospitalization for malaria at the S. Anna Hospital (city of Ferrara), from 1871 to 1901

Time	1871-74	1876	1880-1899	1901
Data source	Scelsi	Vicentini	Celli; Baldassari	Baldassari
Diagnosis: intermittent periodic fevers	721 average:180/yr	201	4009 average: 200/yr	119
total hospitalized/year	10.264	unavailable	61.310	2059
malarial/hospitalized	7%	not calc.	7%	6%

Based on: Scelsi G. Statistica della provincia di Ferrara. Ferrara: Bresciani; 1875; Vicentini ref. Bibliography; Celli A. L'epidemiologia della malaria secondo le recenti vedute biologiche Roma: Soc. Dante Alighieri; 1900; Baldassari L. L'Arcispedale S. Anna in Ferrara nel 1901 – Statistica sanitaria e considerazioni. Atti dell'Accademia delle Scienze mediche e naturali in Ferrara 1902; (III-IV):1-16

The study on the spread of malaria in the 124 garrisons of the Kingdom of Italy, in the three-year period 1877-79, confirmed the limited malarial endemic in the city of Ferrara[33]. The range of morbidities was between 1504 malarial per thousand soldiers in force (Cosenza) to four malarial per thousand soldiers in force (Massa Lubrense, near Sorrento). The garrison of Ferrara presented 157 malarial per thousand soldiers in force, close to the median value (covered by two garrisons, Gaeta and Verona, both with 140 malarial per thousand soldiers in force).

The situation in the rest of the province was quite different: the 1885 survey specified that 87% of the residents in the province of Ferrara were exposed to "severe" malaria, compared to 7% of residents who were not exposed to malaria (tab.2). In addition, the reports of the health officials in the 1899 investigation confirmed the continuing serious epidemiological situation. Argenta: "over half of the population paid their tribute to malaria every year"; Copparo: "here malaria is endemic and cases of marsh ca-

chexia are frequent"; Mesola and Codigoro: "the whole municipality lies in a malarial locality"; Portomaggiore: "very frequent cases on the valley side"[34].

Tab. 2. Health care indicators in the 1885 survey

	Municip. with hospital (%)	Doctors /10.000 inhabitants		Pharmacies		Exposed to malaria (%)		Died of malaria (per 10.000 inhab.)
		In the county town	Others municip.	Municip. without pharmac.	Number pharmac.	serious	mild	
Compartm. of Emilia	27	8,4	4,9	76	565	27	35	1,8
Province of Ferrara	18	5,8	4,5	1	69	87	6	7,1

Legend: Municip. = municipalities; Compartm. = compartment; pharmac. = pharmacies; inhab. = inhabitants
Based on: DGS Risultati dell'inchiesta sulle condizioni igieniche e sanitarie nei comuni del Regno Relazione generale. Roma: Tipografia nell'Ospizio di San Michele; 1886.

In the next period 1900-1902, 50% of the inhabitants in nine municipalities (out of 18 in the Province) suffered annually by malaria: "(malaria) has marked for many years the primacy among the epidemics of the Argenta area although the mortality from malaria was always exceeded by that from tuberculosis, but there was malaria everywhere. No doctor treated a sick person unless he started first by administering the then expensive quinine, because he found malaria present in the patient"[35]).
The determinants of malaria include control measures and therapeutic measures.
In 1885, the province of Ferrara had a welfare budget below the regional average (tab. 2). Until 1900, the only control measure implemented in Ferrara appear reclamations, which became, due to technical inability or insufficient funds, a contributory cause of the malaria resurgence after 1890. As regards antimalarial therapy, health care in the Ferrara area was scarce and difficult, due to both the lack of roads and the shortage of doctors and pharmacies. In 1862, health care is difficult in most rural areas "The outskirts of the territory to be covered even reach 40 kilometers. ... Roads in winter are difficult and disastrous"[36]; but obstacles to health care related to distances and travel difficulties will still exist in 1952. The problem was more acute in the lower Ferrara area: in 1882, the average extension of the area a doctor was supposed to cover in the Comacchio district was 48 square kilometers, versus 14 in the Cento district[37].
Furthermore, add the difficulty for many to access treatment with quinine, primarily due to the high price: the imported quinine salts cost £ 600/kg in 1880. Thanks to the favorable international market, in 1886 the cost dropped to £ 65/kg and in 1906 it went down to £ 45/kg[38]. In 1911, under the quinine legislation, the cost for the municipalities was 6 cents per gram; for the public, quinine cost 8 cents per gram[39]. In addition to

the cost, the use of quinine encountered various other obstacles. Numerous substitutes were used, generally cheaper, ineffective towards plasmodia even when endowed with antipyretic activity, so much so that, since 1859, prof. Bosi warned: "Sulphate was prescribed; we do not know of any other drugs that can do the same against these fevers; instead of doing a boring list of substances that the pharmaceutical pedantry boasts as substitutes". The high profit margin frequently led to sophistication and adulteration of the cinchona bark, against which Antonio Campana[40] himself, already in the 1802 edition, warned[41].

Malaria, with its peculiar clinical manifestations, was cloaked in magical-sacral concepts that shifted the preference towards popular cures: "[the doctors] did not keep silent about the little faith that the locals have in the practices of good medicine, while then they give themselves to charlatanism with lively hope"[42]. The intermittent nature of malarial fevers led to a search for the origin of the disease in a supernatural responsibility: therefore, "folk medicine alternated or associated the natural remedies against fevers and diets with magical symbols"[43]. Hence, the peasant custom of resorting, rather than to the doctor or pharmacist, to figures "who speculate on ignorance, on the sense of the supernatural, false doctors, and witches". Bertani's investigation also records the prejudices concerning the treatment of diseases "with the administration of beverages composed in the strangest way".

The mortality data do not adequately represent the malarial endemic: "mortality could not be taken as a true indication of the greater or lesser intensity of the malarial phenomenon"[44]. This is due to many reasons: the low lethality (in the second half of the nineteenth century malaria was assigned 2-4% of deaths), the clinical complexity, the indirect damages, the consequences on pregnant women and early childhood (not diagnosed as malarial), and the weakness of the geographical link.

However, more important is the consideration of the lack of other sources of information and, later on, the uncertainty of the reports on the number of patients these factors make the mortality statistics a "basic element for evaluating the presence of malaria, its severity and variations of its virulence". This statistic has the advantage of allowing a quantitative historical series, uninterrupted and of fairly constant quality, albeit with intrinsic limitations (difficulty of only clinical diagnoses, especially in children and consequent imprecision in detecting all deaths in which malaria would have been the cause; quality and completeness by the certifiers).

The collection of causes of death began as of 1881 only for the 281 main provincial and district municipalities, and as of 1887 for all municipalities. Fig. 1 presents an indicative reconstruction of the situation prior the year of the start of the statistics in all the municipalities, comparing an average annual mortality rate for the decade 1868-78 (based on data from 18 Italian cities, including Ferrara, reported by Sormani) to the mortality rates of the provincial and districts capitals from 1881 to 1886.

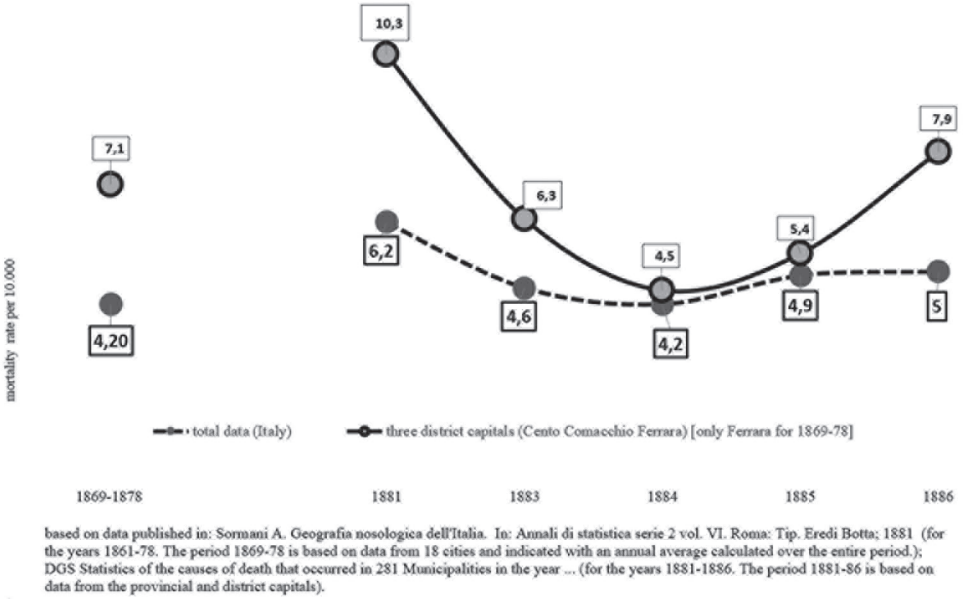


Fig. 1. Malarial mortality in Italy and in Ferrara, from 1868 to 1886 (indicative comparison).

Despite the caution due to the heterogeneity of data, in the '70s and '80s malarial mortality in Ferrara was higher than the national average (and quadruple compared to the regional average - shown in table 2). The peak of 1886 is a typical epidemic re-ignition, which occurred every five years approximately.

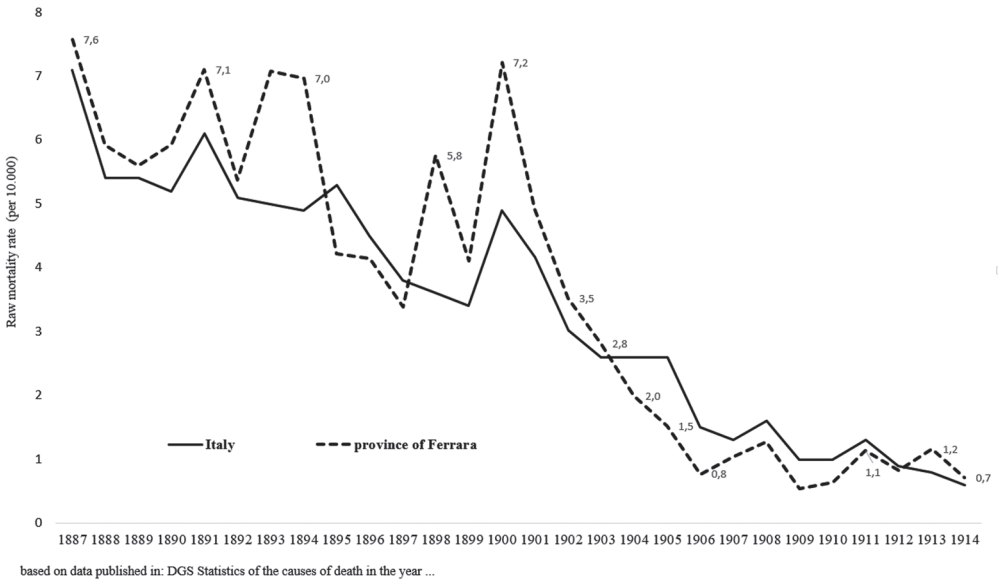


Fig. 2. Malarial mortality from 1887 to 1914, in Italy and in Ferrara

The national statistics of the causes of death began in 1887. Even taking into account the poor quality of information in some areas of the country at least in the first years of this statistic, in Ferrara it shows a mortality higher than the national average up to 1901 as well as five mortality peaks double the national mortality average (fig. 2).
The national figure of work related mortality (present in the first data series of the statistical collections and not reported here) records a high percentage of malaria deaths among farmers and shepherds: "among the poor"[45].
A territorial detail, referring to the last twenty years of the nineteenth century, is available for the provincial capital municipalities and for the municipality of Argenta, only municipality for which there are detailed reports by health officials (Tab. 3).

Tab. 3. Mortality rate from malaria in the district capital municipalities and in the municipality of Argenta (per 10,000 inhabitants)

Year	Cento	Ferrara	Argenta	Comacchio
1881	0,5	11,9	6,4	17,0
1882	1,5	7,9	2,9	14,0
1883	1,5	7,3	1,1	8,0
1884	1,5	5,2	1,7	4,9
1885	0,5	6,3	3,8	8,6
1886	1,5	8,8	6,4	11,5
1887	2,0	5,3	0,5	1,9
1888	1,5	3,5	4,1	10,5
1889	0,0	4,7	5	7,3
1890	0,5	6,4	4,5	9,1
1891	0,0	10,4	4,4	6,3
1892	1,0	2,9	3,4	7,1
1893	0,0	4,7	5,2	16,7
1894	0,5	3,0	4,2	13,0
1895	0,0	2,0	8,8	16,4
1896	0,5	1,9	9,6	9,4
1897	1,0	2,1	10,3	8,5
1898	0,0	2,9	1,6	6,9
1899	0,0	2,0	13,6	8,0
1900	0,5	1,5	16,6	10,9
1901	0,0	3,0	7,2	17,7
1902	0,5	3,4	2,9	9,1
1903	0,5	1,3	1,4	8,1
1904	0,0	0,5	1,9	8,0
1905	0,0	0,8	0	7,0

Based on: DGS Statistics of the causes of death that occurred in 281 municipalities in the year [from 1881 to 1886]; DGS Statistics of the causes of death in the year [from 1887 to 1905]; Orta F., L'Igiene nel Comune di Argenta 1879-1903 Argenta: Tipografia Argentana; 1904; Orta F. Triennio 1904 - 05 - 06. Note di demografia sanitaria e di epidemiologia. Argenta: Tipografia Argentana; 1907.

Cento shows a stable epidemiological situation with low mortality over the twenty years (about 1 / 10,000).
Ferrara has five-year peaks typical of mesoendemia, which have been attenuating since 1895. Comacchio has values on average double the provincial average with recurrent epidemic peaks (mortality exceeds 8 per 10,000 [75th percentile for the data observed in the 25-year period taken into consideration] for 18 out of 25 years). The serious environmental impairment of the city of Comacchio and its surroundings, described by the health official in 1895[46], together with an unfavorable ecological context, could explain the hyperendemic afflicting it.
Argenta up to 1894 shows a similar trend to Ferrara, with three five-year peaks in the same years; from 1895 mortality increased until 1900, due to the negative effects of reclamation (in Argenta the 75th percentile is exceeded for 5 years). Mortality in Argenta (where the antimalarial station was active until 1900) dropped to zero in 1905, while in Comacchio it remained high.
Enea Casorati[47], the health official of Argenta until 1904, referring to the last five years of the nineteenth century, recalls the importance of the indirect damages of malaria ("the mortality figures do not represent all those deaths reported for intercurrent illnesses (especially pneumonia) that would not have occurred if it were not for deeply malarized subjects"). He estimated that in some villages with very high malarial endemic (Longastrino and Filo) and medium-high (Argenta centro and Consandolo) malaria super mortality caused 60% of deaths. He pointed out that in the same localities the mortality under 5 years was between 32% and 40% of births (compared to 29% nationally). In fact, malaria was often an indirect cause of infant mortality due to the malarial infection suffered by the pregnant mother as well as for her working until delivery.

The "Ferrara antimalarial station" and the first twenty years of the antimalarial struggle (1899-1920)

On December 5, 1898, the Provincial Deputation of Ferrara[48] participated in foundation of the Society for the studies of malaria[49]. Undertakings of these Society included legislative proposals in relation to safeguards against malaria that will be approved between 1900 and 1907, and the creation of antimalarial stations to "extend the good results obtained in the stations set up in the Roman countryside". The antimalarial stations have two objectives: 1) reduction in the number of mosquitoes; 2) elimination of contacts between mosquito and man (by means of metal nets and curative and prophylactic quinine)[50].
Next year, in October 1899, the activity of the antimalarial station of Ferrara begins "to study the local conditions and possible application of the prophylaxis that the new discoveries have suggested", with the patronage of the municipalities of Argenta (quite clearly sensitized by the tripling of deaths from malaria in the decade 1891-1900) and Copparo (zone of malarial hyperendemia).

Eugenio Centanni[51] presented the first results in the speech for the opening of the academic year: "In 1900, prof. Celli[52] with the provincial doctor dr. Marchese and with prof. Centanni visited various parts of the Ferrara territory to study the problem of malaria"[53].

In the province, the malarial situation was serious: "The microscopic observation on the blood of many malarials has persuaded us that this [summer-autumn] form is very frequent throughout the season. The lack of severe forms must be attributed to the wide use that is made of quinine here and in part also to the habit acquired by this population towards the disease and to a recent comforting trend in the use of quinine. Today we can see in many homes the bottles of quinine salts that the workers take directly even without the intervention of a doctor".

The study of drainage canals, waterways and other water bodies in ten locations (Argenta, Codigoro, Migliarino, Casaglia, Bando, Lagosanto, Comacchio, Magnavacca, Paviero, Campotto) confirmed the malarigenous characteristics of the Ferrara environment: 1) "the reclamation has changed little or nothing with respect to malaria: the vast network of stagnant canals constitutes the main malarial outbreak in the region". "Anopheles larvae have been found in fresh water canals at all times"; 2) "The hemp retting ponds contain anopheline larvae when the hemp is not retting"; 3) the remaining "stagnant freshwater is an anophelic environment at least for the first half of the season"; 4) The Comacchio valleys never present mosquito larvae". The measures of prophylaxis resumed the indications of Celli: 1. treatment of patients "with generous and prolonged doses of quinine", warning that "the proximity of a patient [of malaria] should not be considered indifferent"; 2. mosquito nets; 3. reclamation of anopheligenic waters.

In 1903, after Centanni's departure for the University of Cagliari, Francesco Orta[54] seems to assume a central role in the activity of the Ferrara Antimalarial Station, centered on Argenta as an area of study and experience: "the Society for the studies of malaria ... gave me the task of carrying out a program[55]". In the documents from the Historical Archive of the Municipality of Argenta, relating to the "Health and Hygiene" category for the first decade of the twentieth century, mention is made of the Antimalarial Station only in the publications of Orta. The limitation of the activity of the Antimalarial Station to the Municipality of Argenta can be deduced from the presence of reports on the activity limited to the Municipality of Argenta and is confirmed, for example, in the observation that the first epidemiological observations were limited to Argenta, "for the other municipalities we received very fragmented reports".

A popular information brochure[56] created in 1900 documents the Station's commitment to education. The activity of the antimalarial station until the arrival of "State quinine" was of an experimental and educational type: "in Argenta the antimalarial campaign promoted by our company started in 1900 and already in 1901 and 1902 quinine prophylaxis was done. The municipality of Argenta, the hydraulic consor-

tium, the Italian-Swiss Agricultural Company contributed to the noble purpose"[57]. In 1901-1902, in patients treated with quinine, infections were reduced by over 66%, with evident social repercussions: "upon the revision of the settlements agreements it was accepted and accepted that the owners provide quinine free of charge to their workers". Nonetheless, the comparison between the 1901 campaign program and the final report for 1902 suggests difficulties in quinine prophylaxis: "the use of quinine according to useful rules is not so popular" observes Orta. The peasants and the poor had to be convinced to take the drug according to specific plans, difficult to accept due to the widespread ignorance and distrust at the popular level. The fight against malaria was essentially based on quinine (the nets were an expensive product; very often also inadequate due to the low quality of the houses), distributed through medical practices: Orta made use of the collaboration of the local medical doctors, who sometimes appear as co-authors in the reports; there are no references to auxiliary personnel or antimalarial dispensaries.

The large number of laborers ("In the province of Ferrara, between 1871 and 1901, stable agricultural workers - tenants, sharecroppers, herdsmen - decreased from 50,000 to 36,000, [..] the laborers instead increased from 12,000 to 45,000 "[58]), poor and with little employment made Ferrara one of the most socially unstable areas of the country. During the Giolitti age (1903-14), consistent reclamation works were carried out also to respond to job demands on part of the laborers' leagues[59]: construction of the Botte del Burana outlet channel; changes to the drainage network of eastern reclamation and upgrading of the Codigoro drainage systems; start of the Rhine reclamation. The State Quinine Law required the identification of malarial areas. The classification of malarial areas in the Ferrara area was established with the R.D. n. 201 of 8 March 1903 and subsequently expanded in 1904 and in 1906: only four municipalities, out of 18, remained free[60].

Starting on July 1, 1903, the distribution of State Quinine began in the tobacco-selling monopolies: "The State assumed the burden of purchasing guaranteed quality quinine on the international market, packaging it in tablets and distributing it in the malarial areas included in the program. The drug would be provided free of charge to the poor and to all those who worked outdoors"[61]. In a few years, thanks to the activity of the anti-malarial chair (and the local Labor League), the acceptance of quinine evolved favorably in Argenta: "The workers of the land in the malarial areas of our province ask for quinine directly and take it with the same fervor that they put into their struggles for economic redemption"[62]. The effectiveness of the interventions conducted at the beginning of the twentieth century shows in Fig. 3, with the halving of the percentage of malaria in the three-year period 1904-7, since the arrival of state quinine in all the municipalities under investigation.

An unpublished letter[63] from the Mayor of Argenta to the Minister of the Interior summarizes the synergies put in place and the results achieved in the first nine

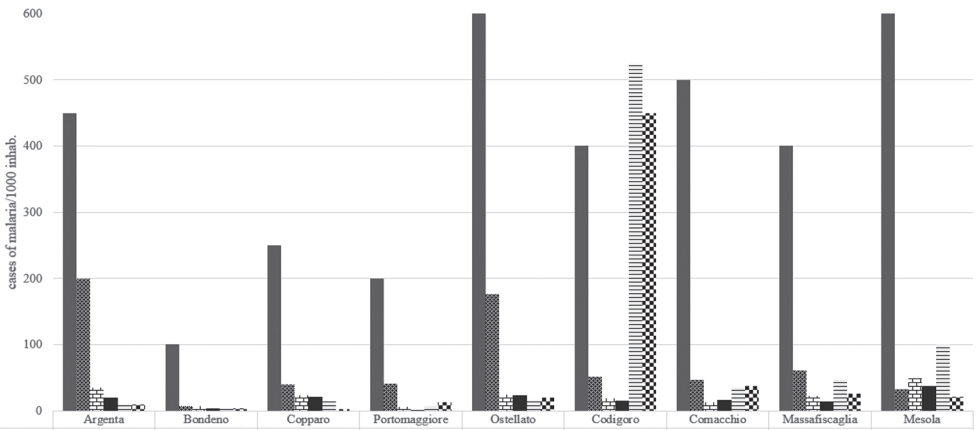
years of the fight against malaria. “While a decade ago the average morbidity was between 40 and 50%, now we are down to minimum percentages (4%) with the firm confidence we will see them still decrease. The most important part is up to the Hygiene Office and the municipal doctors who do their best to implement the laws on malaria (...) for the distribution of quinine and the identification for the sick. The municipal administration did not fail to assist the hydraulic consortium in the execution of those works that reduce the permanent causes of the malarial environment. Concerned about the conditions created by the periodic unemployment of the occasional workers, it carried out several road works in the marshy area, having the Technical Office take into account that the lateral drains be arranged to permanently remove stagnant water. For its part, the Consortium Administrator has built solid riverbanks for a long stretch of its hydraulic district; it has also regulated the waters of a vast area with a new network of canals, correcting a primitive deficiency; has expanded its drainage plant by increasing its potential. The same Administrations have not failed to favor the application of mechanical prophylaxis means, pushing private individuals and the Agricultural Company to install metal meshes in homes”.

Since 1902, following the requirement to report cases of malaria, it should have been possible to follow the evolution of morbidity. However, the completeness of reports of infectious diseases has always represented a critical issue; even more so for malaria where clinical diagnosis is not a sufficient criterion and not all patients consulted a doctor, due to the distance or cost of the visit or cultural factors. In addition, the interests of landowners (they had to pay quinine to employees) and of municipal administrations (they had to pay quinine to the poor) stood in the way: “Some municipalities, in violation of the law, omit reporting malaria cases in order not to be burdened by the expenses that the law imposes on the Municipalities and, for them, on the owners of the land in the malarious areas”[64].

Malarial morbidity data in the first fifteen years of the twentieth century in nine municipalities of the Ferrara province with malarial reclamation are accompanied by the clarification “I checked the data with colleagues”[65]. According to these data, starting from 1904, the number of malaria patients began a decisive decline in the nine municipalities, a decline probably due to the synergistic effect of the increased availability of quinine, the improvement of hygienic conditions and the economic improvement reported for the Giolitti age[66] (Fig. 3).

In a decade, the amount of quinine supplied to the municipalities of Ferrara by the State Quinine Company doubles: 128.53 kg had arrived in 1905; in 1914 became 288.63 kg (Fig. 4).

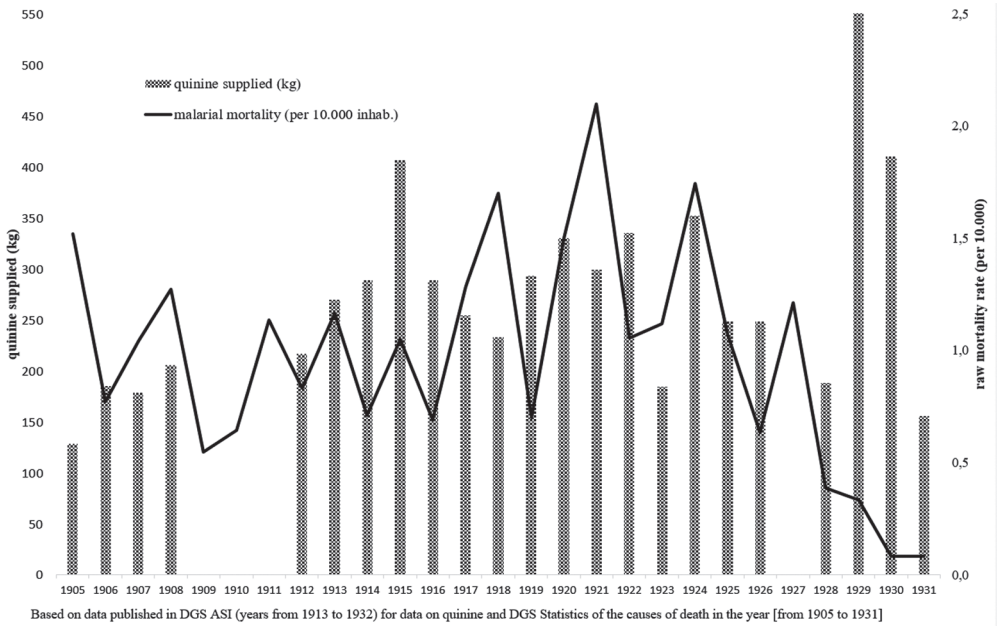
In the five-year period 1887-91, Ferrara had had a mortality rate of 6.4 per 10,000 compared to the national mortality rate of 5.8 per 10,000 (the highest mortality was Cagliari with 35.2 per 10,000).



	Argenta	Bondeno	Copparo	Portomaggiore	Ostellato	Codigoro	Comacchio	Massafiscaglia	Mesola
1900-2	450	100	250	200	600	400	500	400	600
1904-7	200	7	40	41	177	51	47	61	33
1908-11	35	7	24	6	25	19	13	22	49
1912-15	20	4	21	1	24	15	16	14	37
1922-24	9,5	3,6	14,2	7,7	16,3	524,7	35,3	46,8	100,3
1925	9,3	4,1	2,1	12,6	20	449,1	37,4	26,1	21,3

Based on data published in: Orta F. La lotta alla malaria in provincia di Ferrara. Ferrara: La rivista, 41(28) 8 aprile 1917; Ottolenghi D. Brotzu G. Intorno all'azione esercitata dalle bonifiche sull'endemia malarica nel Ferrarese. RIVMAL 1927 2:268-322

Fig. 3. Malarial morbidity in nine municipalities of Ferrara province, years 1900-1925 (patiens/year per 1000 inhab.)



Based on data published in DGS ASI (years from 1913 to 1932) for data on quinine and DGS Statistics of the causes of death in the year [from 1905 to 1931]

Fig. 4. Quinine supplied to municipalities by the Company for quinine and malarial mortality in Ferrara from 1905 to 1931.

In the five-year period 1905-9 Ferrara has a mortality rate of 1 per 10,000 compared to the national average of 1.4 per 10,000 (the highest value is always Cagliari, with 10.3 per 10,000)[67].

Until 1915, malarial mortality in Ferrara stabilized to one death per 10,000 inhabitants. The lack of a linear relationship between quinine supply and mortality highlights the epidemiological complexity of malaria due to the interconnection of ecological, biological and social factors.

Despite the decrease in malarial mortality, the criticisms on part of the medical-academic current about the strategy of quinine prophylaxis in the healthy remained: "The quinine prophylaxis has helped by putting quinine within everyone's reach [...] Only treatment allows the doctor to fight effectively against malaria, since it is certainly less difficult to treat a limited number of patients, rather than pursuing the unattainable aim of treating with quinine entire populations for prophylactic purposes"[68]. The criticisms were also resumed in the local press[69] and Orta intervened in the diatribe contesting those who argued the harmfulness of the use of prophylactic quinine: "on the basis of nine years of daily observation of clinical facts, these inhabitants have never been as prosperous as they have been since taking quinine"[70].

In 1916, Orta believed that it was possible to further improve the result achieved by adding together anti-Anopheles measures, intensive treatment of malaria, widespread and rational quinine prophylaxis and educational propaganda by improving the malarigenous environment through "the small reclamations in the great reclamation that is the agricultural reclamation in its true sense"[71]. In this article, was published in "La malariologia" (edited by Ernesto Cacace), Orta qualifies itself as Director of the Ferrarese Section of the educational-antimalarial and hygienic-antimalarial station of Naples and Capua and Director of the itinerant Chair of antimalarial hygiene for the province of Ferrara, specifying: "As of 1913 we have adopted the method of prof. Cacace which is very practical and effective". With Italy's entry into the war, preventive measures slowed down due to the subtraction of funding and personnel, swallowed up in the war effort, the deterioration of living conditions and the worsening of land maintenance. "In recent years, in the Ferrara area, malaria has caused several deaths, and in 1915 malaria caused 23 deaths, among them many children. We had been several years without any deaths"[72].

The "Ferrara Section for the study of malaria in reclamation" and the next twenty-five years of fight against malaria (1920-1945)

Even in Ferrara, the slowdown in anti-malarial measures during the conflict and the return of malarial veterans eroded the progress achieved in the pre-war period, with a rise in morbidity everywhere as shown in Fig. 3; the case of the Municipality of Codigoro is emblematic: it returned to levels of morbidity equal to those of the late nineteenth century. In the inter-epidemic period 1922-3, Rodolfo Viviani e Giuseppe Martinelli, from the University of Bologna, verified the extent of latent malaria in the nearby Municipality of Mesola by examining 106 children from Goro and 40 children from S. Maria in Bosco, Torre Abbà and Gorino. Latent malaria was present in 42%

of children in good health conditions, while following quinine treatment negativized 60% of them[73].

Anti-malarial activities in the post-war period appear based on a bureaucratic approach centered on quinine: "[The Directorate General of Health] admitted to having pursued with strength and means above all the work of quinization of the population but neglected to encourage and control the interventions of disanophelization with the use of larvicides, and small land reclamation"[74].

This approach is confirmed in the report of the provincial health official Giuseppe Monti on the anti-malarial campaign of 1923[75]. He bets everything on quinine and shows little faith in small reclamations, because the physical characteristics of the territory. Yet, he evaluated the health situation as "improving", despite 6579 patients treated, 2461 detailed clinical diagnoses and 31 deaths, and the signs of a resurgence reported by the two researchers from the University of Bologna. Indeed they wrote: "Except for a few sporadic cases of infection occurring occasionally in some towns in the upper Ferrara area, it can be said that by now malaria was limited only to the lower Ferrara area. Recently, however, the infection has made its reappearance in a fairly significant proportion in the localities of Ravalle, Porporana and Casaglia, in the Municipality of Ferrara, where some hydraulic reclamation works were suspended during the war". The two researchers were enrolled in the 1923 campaign to support the antimalarial action of the Delta doctors. Their in-depth diagnostic investigations shows a meso-endemic epidemiology: from the 14% of the men examined in Ariano were malarial, to the 26% in Comacchio, until the 36% in Goro and Gorino.

After the war, began the reclamation works neglected during the conflict, including many small reclamations, and started the reclamation of the Trebba, Ponti, Raibosola valleys in the Comacchio area and the Mantello and Destra Reno valleys in the Argentano.

However, the criticality of the socio-economic situation did not change.

Ferrara remained a hodgepodge of structurally under-employed laborers ("At the 1931 census the families of day workers and sharecroppers numbered 97,000 people - out of 232,000 employed in agriculture) and social imbalance was very strong ("1% of landowners - 33 people - held 41% of the taxable income"[76]) and contributed to the affirmation of agrarian squadronism in 1921 in the Ferrara countryside. This unstable situation originated numerous protests even in the years following the coming to power of fascism. The presenters of the reclamation land program argued that: "it is not true that the Ferrara area is not capable of supporting all its children. We only need a more rational demographic distribution"[77]. To this aim, fascism took hold of some critical instances of the reclamation model, which evolved in the first decade, advocating the conversion of the reclaimed areas to intensive agricultural activity and relocation. In the measures passed between 1923 and 1934, the goal of eradicating malaria was included in a broader strategy: recovering the territory to stabilize

masses of unstable laborers and peasants[78]. The fascist regime tried to curb the explosiveness of the Ferrarese workers with the so-called "sbracciantizzazione (change in status of the position of day laborers) of the Ferrara area" which provided for: 1) sharing (which forced laborers to reside in the reclamation); 2) employment of a fixed number of laborers (which forced owners to hire seasonal workers); 3) transfer of the largest possible number of families living in Ferrara to reclamation areas through the Colonization Authority of Ferrara (the transfers of Ferrarese laborers to the Agro Pontino and Sardinia produced the first real demographic decline in Ferrara in 1931-36[79], contributing in part to the attenuation of malaria in the Ferrara area). In the Ferrara area only 350 houses were built out of 6,000 planned[80]; the complete reclamation resulted in loans to large landowners.

In order to create a more effective antimalarial strategy[81], in 1925 Alberto Missiroli[82], in collaboration with the Rockefeller Foundation[83], created in Rome the "Experimental Station for the fight against malaria" through both the study of local conditions and the antilarval interventions by Paris Green[84]. The Station would have demonstrated the effectiveness of the struggle based on the integration of the anti-larval fight with quinine treatment of the population.

The Experimental Station developed into a dozen of peripheral sections, located in selected areas. Among these, prof. Donato Ottolenghi[85] created, in Ferrara, the "Section of the Experimental Station for the study of malaria in reclamation". This Section was supported by the Malaria Commission of the League of Nations, who agree with the Ottolenghi's proposal to study the action of reclamation on malarial endemic, in response to malariologists who believed that reclamation did not had no direct effect on pre-existing malaria[86].

The "Section for the study of malaria in reclamation", with funding from the Ministry of the Interior and from the Rockefeller Foundation[87] and the support of the municipality of Ferrara and the municipality of Jolanda di Savoia, installed a research laboratory at the premises of the University of Ferrara with a staff of five researchers (including Giuseppe Brotzu[88]).

This Section adopted a rigorous working method ("The fight against malaria must always be carried out according to a precise, complete program, adapted to local conditions")[89], and trained local operators. He applied the strategy supported by the Rockefeller Foundation, carrying out investigations on the role of determining factors with malariologists and entomologists in every locality. Indeed, the work began with the examination of the local sanitary conditions and identified three locations with highly differentiated characteristics: Jolanda di Savoia (reclaimed, a very little malarial), Diamantina (reclaimed, malarial) and Gorino (not reclaimed, very malarial). In these localities, investigated the entire malarial determinant, including the sweep of plasmodia carriers. The results exemplify the strategy of "local study of the contact between anopheles and man". (Tab. 4).

Tab. 4. First study of the anopheles-man contact by the Ferrara Section for the study of malaria in reclamation (1925). Main results.

	Jolanda di Savoia	Diamantina	Gorino
Physical characteristics	hydraulic and agricultural reclamation completed, large canals well managed, smaller canals dry in summer	imperfect hydraulic reclamation, no agricultural reclamation	valleys, with fresh water from the Po di Goro
Area studied (sq. km)	10	4	1,4
Inhabitants	2247	192	402
Malarial epidemic	free	serious	serious
Splenic rate [(90)]	3,7%	66%	44%
Carriers of plasmodia	carriers: 1%	carriers: 35%	carriers: 47%
Positive infants	0	25%	50%
Socio-economic conditions	fair	poor	excellent
Nutrition	fair	poor	excellent
Crowding (inhab./room)	4,4	3,5	3,9
Generic health care	good	good	good
Means of defense against anopheles	Windows close before sunset	Windows close before sunset	Windows close before sunset
Most numerous anopheles species	*A. maculipennis*	both	*A. sacharovi*
Anophelic density	light	medium	very wide
Behaviors of anopheles: 1. they sting humans when they are in homes	all	all	all
2. can become infected	all	all	all
3. go to the stables	Yes, quickly	slowly	No (there are no stables)

Based on: Ottolenghi D, Brotzu G, Intorno all'azione esercitata dalle bonifiche sull'endemia malarica nel Ferrarese. RIVMAL 1927 2:268-322

Jolanda di Savoia, in the heart of nineteenth-century reclamation, was found almost free of malaria: "causes of the absence of malaria in Jolanda are the reclamation, with marked lowering of anophelism, the extreme scarcity of gametophores, the wealth of livestock, the trend of Jolanda's Anopheles to abandon the homes".

On the basis of the recorded splenic rate[90], extended from 12.5% in Jolanda di Savoia to 72% in Diamantina, it is possible to quantify the malarial situation in the Ferrara area in 1925 as mesoendemic with areas of hyperendemic: therefore there was high vulnerability in large areas of the Ferrara Province.

The first anti-malarial campaigns were based above all on hydraulic reorganization works and on the fight against larvae with Paris Green.

The struggle of the Section started from Diamantina[91], a rural locality near the city of Ferrara with a malarial recrudescence in progress. The Section's research photographed the deterioration of the environmental conditions in these suburb of the city ("here [Diamantina] the reclamation was very imperfect with faulty water drainage"). The excavation of the Boicelli channel[92] and the concomitance, in the years 1924-26, of a very high humidity (> 60%, never recorded since 1900), which facilitated the increase in anophelic density, expanded malaria to a large portion of the municipal territory.
The larvicidal intervention affected an area of 30 square kilometers between the province capital and the Po River. The effects was monitored with 45 control stations and show good results: a 76% reduction in malaria morbidity in the reclaimed area, against a 42% reduction in the control area; the attenuation of the endemia with reduction of the splenic index (15% versus 65% in the control area); the disappearance of the larvae. Fig. 5 shows the malarial situation of the municipality of Ferrara in the period considered and the effectiveness of the intervention led by the Section[93].
The high number of malaria cases observed in the Municipality of Ferrara in the years 1927-1928 was attributed to relapses.
The availability, since 1929, of Plasmoquine, a synthetic antimalarials gametocide against P. falciparum[94], prompted the Ferrara Section to add the "pre-epidemic human reclama-

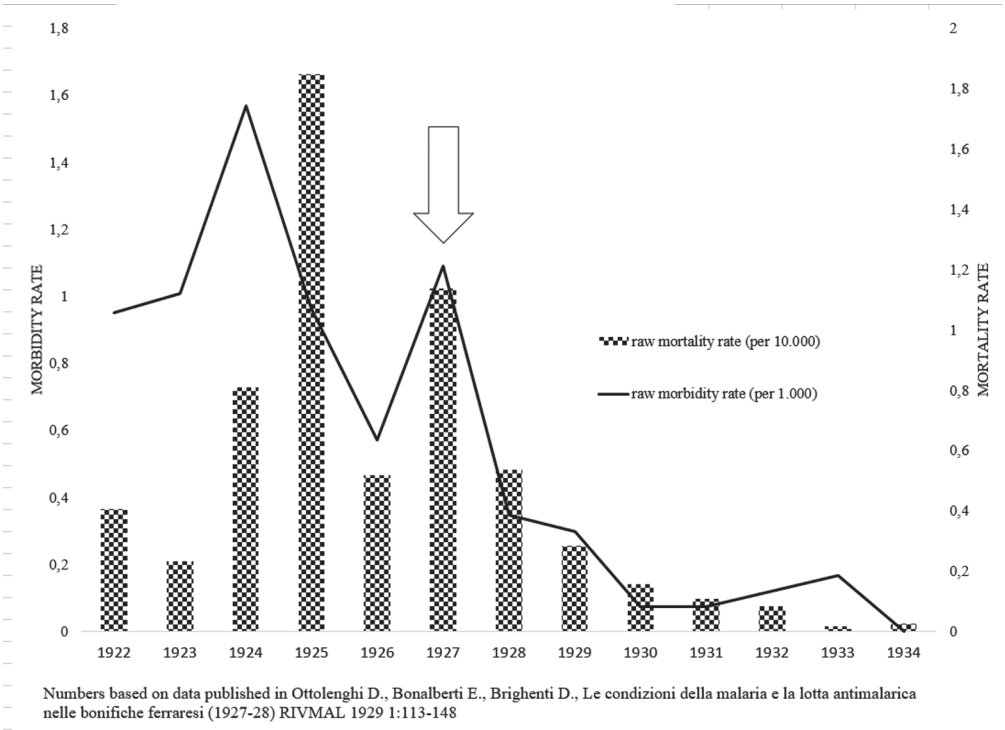


Fig. 5. Malarial epidemic in the municipality of Ferrara (1922-1934)
(the arrow indicates the reclamation planned by the Section)

tion" (radical cure of malarial people in order to avoid infection of the anopheles[95]) to the antilarval fight. This renewed activity, to reduce the vulnerability, was achieved through annual campaigns; "in medium or mild endemic areas, such as in the Ferrara or Ravenna areas, there have been really good results[96]". In the area of Gorino, the new method achieved a reduction in morbidity of over 90%[97]. The Section also applied the method in Ravenna, with identical results[98]. In the years 1931-32, the pre-epidemic human reclamation method, applied also in Portoverrara, obtained a 95% reduction in morbidity[99].
The working strategy was broadened in 1934, when the Section organized the campaign program on behalf of the newly formed Provincial Antimalarial Committee of Ferrara: treatment with antimalarial plus distribution of insecticidal liquid plus malariologica surveillance until winter season. Furthermore, the malaria patients, of two inhabited centers under very different environmental conditions, were subjected to human reclamation: San Giuseppe (449/1600 residents, with an 85% reduction in morbidity), and Gorino (482/506 residents, with a 45% reduction). The lower effectiveness of the intervention on Gorino was attributed to the impact of malaria present on the nearby Ariano Island in whose rice fields part of the inhabitants of Gorino went to work. The control area consisted of three nearby inhabited centers (Monticelli, Vaccolino and Volano), where only therapeutic quinine was offered: 80% more cases of malaria were recorded than the previous year[100].
The anti-malarial campaign of 1935 extended the pre-epidemic reclamation to all five locations involved in the 1934 campaign, while a mass cure was carried out in Boschetto di Lagosanto (225 treatments in November) as an experimentation of an alternative method to the pre-epidemic treatment. All the interventions obtained a strong decrease in morbidity, albeit with differences between the locations subjected to prophylaxis, while the insecticide liquid was not very effective (attributed to the poor quality of the houses)[101].
Starting from 1936, the Provincial Antimalarial Committee of Ferrara directly programmed the campaign of the antimalarial fight in the Lower Ferrara area and supervised its implementation with his own staff, applying pre-epidemic human reclamation for patients and carriers through 15 auxiliary operators[102].
The action of the Ferrara Section drastically reduced malarial incidence and demonstrated the importance of studying local conditions, of combining the radical treatment of all malarial cases with the fight against anophelism and of having an agile organization made up of on-site technical staff. Beside a certain attenuation of the vulnerability produced by the Ferrara demographic decline of the 1930s, the effectiveness of the activity of the Station can be seen in the trend of malarial mortality in Ferrara. After a worsening in the post-war period with four peaks in mortality between 1918 and 1927, starting in 1928 malarial mortality in the Ferrara area remained below the national average, was zero in 1934 and in 1940 and close to zero in 1938 and in 1942 (Fig. 6).

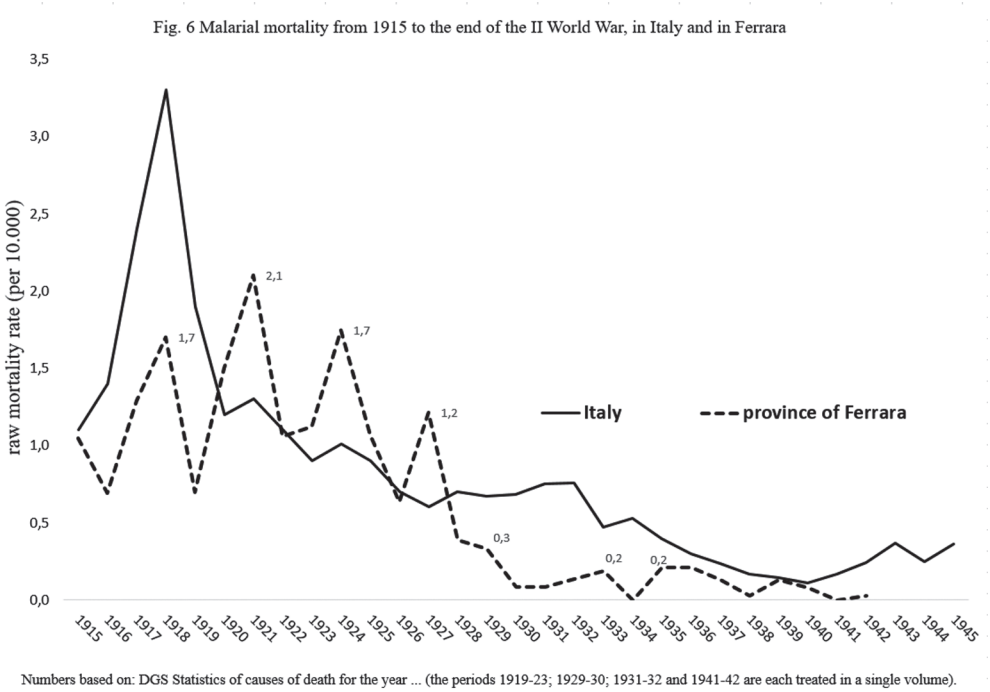


Fig. 6. Malarial mortality from 1915 to the end of the II World War, in Italy and in Ferrara.

National mortality during the 1930s had a dissimilar trend, due to the difficulties in the generalized implementation of the anti-malarial means of defense, as well as to the increase in population pressure in the countryside and the worsening of the hydraulic system conditions[103].

The excellent results in Ferrara were nullified by the neglect generated above all by the German occupation; however, the intense activity carried out in Ferrara until the outbreak of the Second World War, reducing vulnerability to levels close to zero created the conditions for the success of the elimination campaign of the years 1946-1950.

The campaign with DDT and the next twenty years: consolidation of the elimination of malaria (1945-1966)

During the war, the malaria prophylaxis suffered because of the economic restrictions, the lack of supplies, the neglect of maintenance. After the war, the Ferrara area had to face the consequences of the war: thousands of hectares of land submerged due to damage to the drainage systems, destroyed bridges, centers razed to the ground, countless craters filled with stagnant water.

“Those who visited the reclamation of the Ferrara area after the war could ascertain in what poor conditions they were. It really seemed that in many areas ...these territories could not be reclaimed. At the Argenta pumping plant there were only

corpses and shattered landing craft. It was a view that shocked and made people fear for the future"[104].

An (anonymous) report named "Notes on health and hygiene conditions for the second quarter of 1945" describes the health situation of the Argenta municipality at the end of the war: "The definition of a malarial area given to our country, and which only three years ago was a memory of other times, is now fully topical. Numerous primitive and recurrent forms, multiple causes: first of all the swamping of vast areas of land flooded for war purposes and no longer reclaimed"[105].

The environmental worsening combined with the relaxation of prophylactic measures led to a resurgence of malaria in the province of Ferrara. Year after year, malaria grew until 6888 reported cases in 1946.

Tab. 5. Reported cases of malaria in the province of Ferrara and comparison with the national indicator (1941-1952)

	1941	**1942**	**1943**	**1944**	**1945**	**1946**	**1947**	**1948**	**1949**	**1950**	**1951**	**1952**
malaria cases in Ferrara (number)	1169	1999	2431	2130	5997	6888	2222	264	31	5	0	0
Ferrara: malaria morbidity rate (*10.000)	29.7	50.5	61.4	53.8	151.5	180.6	53.3	6.3	0.7	0.1	0	0
Italy: malaria morbidity rate (*10.000)	26.3	36.3	/	82.2	90.1	81.1	46.3	20.1	4.2	0.8	0.1	0.03

Based on: Manzotti A., Paccagnella B. I comuni del Delta padano. In: ACAA, Milano; Giuffrè ed.1954; WHO - Informations sur le programme de lutte antipaludique en Italie -17 avril 1956. Doc. WHO/Mal/163-7

The socio-economic situation of the lower classes remained terrible: "the living conditions of the rural population are primitive and miserable, incompatible with the minimum demands of civil life"; "In this area of considerable agricultural wealth there is the highest winter unemployment and the highest summer unemployment of the whole peninsula". The study on extreme poverty found that in the Po Delta the income of many families was insufficient to ensure minimum living standards[106]. Health care remained complex due to communication difficulties and the lack of resources and facilities (for example, one medical practice had an average extension of 3,770 ha)[107].

In January 1946, Missiroli presented a plan for the eradication of malaria in Italy, through the indoor application of residual-effect insecticides. In the summer of 1946, treatment with DDT also began in Ferrara[108]. The procedure involved sprinkling with a DDT solution (2 g/m^2) the interior walls of houses and stables, starting from the height of 1.5 m from the ground (because the anopheles active in Italy are not used to settling below this height). The frequency of DDT spraying was once a year, because DDT remained active for six months on the walls and the malarial trend in Italy was seasonal. In 1945, in Italy 386 deaths from malaria were recorded; in 1946, they dropped to 279; in 1947 the campaign covered most of the malarial areas and 91 deaths from malaria were recorded[109].

No deaths from malaria were recorded in Ferrara after 1945.
The success of the campaign depended on the residual efficacy of DDT, on its repellent action and on the lack of development, in the first years, of resistance to DDT in mosquitoes, but also on the simultaneous research and treatment of patients and carriers.
To alleviate the poverty of laborers, the Parliament approved the Agrarian Reform with the "Stralcio" Law (n. 841/1950).
In Ferrara, the "Ente Delta Padano", set up to implement the reform, expropriated 44,200 hectares, assigning them to 5,091 families. Consequently, tens of thousands of laborers found themselves deprived of land, assigned in partnership before the reform, and therefore of income and food integration. The simultaneous change of crops from hemp, which allowed sharing, to fruit growing, in which sharing does not apply, determined mass unemployment and high emigration numbers (about 4,000 inhabitants left the Delta every year, with a reduction of 30% of the inhabitants). For each emigrant, another managed to survive and by decreasing the crowding in the houses, the risk of malarial infection decreased[110].
In 1949, in Ferrara the primary infections were 28 and in 1950 the reported cases of malaria were only five, diagnosed as recurrent infections by P. vivax; since 1951 no more cases of malaria were reported. A survey conducted in 1952 in all the malarial areas did not find any positives in Ferrara and here it revealed a splenomegalic index of 1.82%. This index dropped to zero over the next two years.
As Mario Coluzzi[111] taught, malaria vector populations are not homogeneous entities. Indeed, *An. sacharovi* was still present and expanded its range, favored by the presence of brackish water[112]. For this reason, insecticide treatments continued until the mid-1950s.
The endemic malaria in Ferrara disappeared as a result of DDT but, considering the persistence of *An. sacharovi* after 1950[113], also due to changes in the ecological context (improvement of drainage systems and new agricultural methods eliminated larvae multiplying environments) that reduced receptivity and vulnerability (improved health care eliminated gametocyte carriers).
The partial success of the anti-malarial campaign was sanctioned in 1956 (DPR n.1482/56) when seven municipalities (Ferrara, Massafiscaglia, Migliarino, Copparo, Berra, Formignana and Jolanda di Savoia), equal to 49% of the Ferrara population, were declared free of malaria.
The combined effect of the action of DDT and the changes in the ecological context has consolidated the eradication of malarial parasites, despite the persistence of a residual anophelism ("In Italy there has been no sign of resistance and the eradication of malaria has been virtually achieved even though vector anophelines still persist in certain provinces[114]").
An. sacharovi disappeared from Northern Italy in 1959[115].
In 1965, in the Ferrara area the reclamations not yet completed were interrupted.

In 1966, after a further period of surveillance, the last seven municipalities (Argenta, Comacchio, Mesola, Lagosanto, Codigoro, Portomaggiore, Ostellato), equal to 26% of the Ferrara population, were declared free of malaria (DPR n.229/1966). The "colossus with feet of clay", described by Giovanni Battista Grassi as early as 1901[116], had finally collapsed.
In 1970, the World Health Organization included Italy among the malaria-free countries, committing the Italian government to continue the surveillance on residual anophelism. Since 1972, the Regions are in charge of this surveillance. According to the "Information system of infectious and diffusive diseases" (Ministerial Decree of 15 December 1990), malaria entails mandatory notification and special investigations. In the last twenty-year period (1999-2019) the Information System reported in Ferrara 99 confirmed cases of malaria (average 5/year)[117]. The epidemiological investigations have verified in all cases a compatible history of travel to malaria areas abroad: this is the main health problem represented by malaria today in Ferrara and the whole temperate zone[118].

Bibliography and notes

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Abbreviations
AAD: Atti del 2° Convegno L'azione della medicina sociale per la rinascita delle aree depresse.
ACAA: Atti del Congresso internazionale di studio sul problema delle aree arretrate.
AIAC: Annali dell'Istituto Alcide Cervi.
ASC-A: Archivio Storico del Comune di Argenta (FE).
ASI: Annuario Statistico Italiano.
ASSM: Atti della Società per gli studi della Malaria.
DGS: Direzione Generale di Statistica.
RIVMAL: Rivista di malariologia.

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