

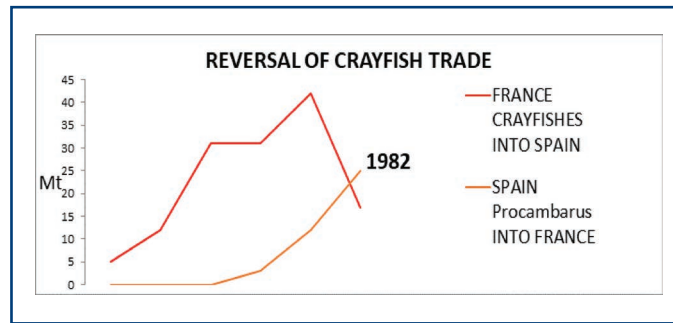
RIVER CRAYFISH IN SPAIN

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With the collapse of all European populations of crayfish, starting with the 1860 introduction into Italy of *Orconectes* crayfish, historical supplies of this traditional Spanish food item became increasingly difficult to obtain from habitats within Spain. Some imported live supplies of non-native crayfishes began to find their way into Spanish cuisine, primarily from populations of *Astacus leptodactylus* from Turkey. Eventually that Turkish source also failed due to their susceptibility to waterborne infections. By 1958, these infections were first documented in Spain. By the 1970s, the availability of any crayfish to Spanish consumers was severely restricted. What little was available primarily came in through French imports, creating a negative trade deficit and funneling Spanish money into France.

This was the situation 44 years ago, when I was in the capital of Seville and gave a lecture as the person responsible for freshwater aquaculture in the government. The guests at the conference were divided in the room. In the first rows next to the platform were the owners of the rice fields, behind them were some rice farmers who worked the land and, in the back corner of the room, the fishermen. I was among other directors on the stage from the governmental entity responsible for inland fisheries called Instituto Nacional para la Conservación de la Naturaleza ICONA (Institute for the Conservation of Nature). I begged fishermen to leave the seats at the back of the room and occupy the nearby rows of lecturers. They got up *en bloc* and approached the stage between the wooden seats with a certain rumble.

Once silence returned, I began to present an idea that had already been exposed to the authorities in Madrid on many occasions: it is a work that we have to achieve together — fishermen, rice farmers, landowners, scientists and even politicians. That a new species of crustaceans will be imported into Europe, then called “crayfish from the marshy areas” to the right bank of the



*By 1982, due in large part to the introduction of *Procambarus clarkii* to Spain in 1974, the country became a net exporter of crayfish to France.*



*In 2019, Don Andrés Habsburgo (center) met with grandsons of *Procambarus* pioneer Rafael Grau Viel. Since the initial introduction, the Grau family have now been processing Spanish *Procambarus* for three generations.*

Guadalquivir River in the province of Seville. That, according to those responsible for breeding crayfish of the species *Procambarus clarkii*, was an ideal location for an introduction and a center of crayfish culture. The place of introduction chosen for the first trial was a separate isolated field. It was near a pump station with an irrigation supply channel and a drainage channel. There were two access roads with no trespassing rights as the lanes ended at the embankment that forms the river bank with its “salt plug” depending on the tides of the Atlantic Ocean.

All responsible precautions had been taken to avoid the spread of Myxomatosis in rabbits from the 3.3 cultivated hectares of the estate of French doctor Paul Felix Armand-Delille in 1952. As Spain is a great wine producer, the arrival of Phylloxera was ominous. I thought it was a good start to talk about invasive species. The disease comes from America but also the cure comes from America.

There were already the major premises for “water-flooded agriculture” or use of land in polyculture: rice, water, paddies, men with the desire to undertake. I found them all in Mr. Rafael Grau of the Casa Alta farm, Isla Mayor. Once these necessary elements were found, the expert from Louisiana State University spoke about crayfish — not tilapia or catfish.

Their criteria were a secluded site, surrounded by waters that increase in salinity. That the annual sheet of fresh water is elementary to a paddy, so that salinity does not rise through the capillary system of the soil. That all the facilities such as the leveling of the land, with a channel of water inlet higher than the drain, the levees and the floodgates of the changeable water level, like in a pond, already existed. Everything necessary with reference to the terrain, climate and availability of a water cycle managed by man was in existence. What was missing was the law to use the intentionally and seasonally flooded agricultural land for aquaculture or astaciculture as well as the movement of the species from one continent to another.

The very good, 109-year old water law in Spain was outdated



LEFT: Spanish *Procambarus* fishermen adapted their years of frugal eel capture practices to find the most economical ways to set, check and transport items around the 70,000-ha rice growing region west of Sevilla. RIGHT: Originally used for the capture of local eels, handmade nets to capture *Procambarus* quickly became a profitable secondary industry for the townspeople of the village of Isla Mayor and surrounding area.

due to research and practical applications of aquaculture on agricultural land. The suggestion for a change in the law was already initiated by me around 1965. So it was, entrepreneurial men — and there were many of them — began the arduous and complicated task of creating a new water law for Spain and weaving connections in different places in the world to establish a new industry.

We chose a kind of crayfish that needs the opposite sexes to reproduce, no known parthenogenesis or virgin birth, a species with an initial yield for the farmer and the fisherman until a production level is established that allows the establishment of processing centers, and a species with a high degree of resistance to warm water and drought. Finally in 1975 a paradigm shift took place in some rice fields on Isla Mayor that involved a land use change in the Marismas from grazing agricultural land, as practiced since the 1930s, to irrigated rice.

The area was selected by Professor James Avault of LSU for the availability of water and because there was no species of autochthonous or alien crayfish such as the *Astacus italicus* or other species of commercial value such as the eel or glass eel that once traced the Guadalquivir River up to Alcalá de Gudaíra. The book *El Cangrejo* confirmed the total lack of crayfish species in the Andalusian provinces.

The crayfish de las Marismas is the largest crustacean species of temperate continental water. Its special adaptation is the wide gills to extract the little dissolved oxygen from the slow running waters, resistance to high water temperature, the female with a seminal receptacle, and an animal that digs into the bottom and builds a burrow with the classic chimney.

Another advantage the American crayfish has over the



*With a minimum of investment, local men, young and old, were able to participate in the profitable, baitless capture of introduced *Procambarus*, interfacing well with other forms of erratic seasonal employment provided by forestry, agriculture and olive industries.*

European species is resistance to disease caused by a fungus that was inadvertently brought as ballast, in a wet sack of hemp, on a ship from the New World around 1850. The reference to the appearance of a new disease dates from 1860 in the Po River in the province of Lombardy in Italy. This disease is a tubular fungus that does not reproduce sexually but through a host. In the case of *Aphanomyces astaci*, the host is the cuticle of crayfish — irrespective of species — and in wet conditions. In 1898, Dr. Hofer of Munich described the disease as a bacterium and

baptized it with the name *Bacillus pestis astaci*.

The capture, quarantine, packaging, air transport, customs at the Madrid Barajas airport, sanitary inspection and the night trip to the Isla Mayor I describe elsewhere. Mr. Rafael Grau wrote in 1974 of the total failure of the stocking, but when I visited his rice paddy later, I showed by digging with my hands in the soil of the field that he was not correct. We set up a company and started crayfish production. The news of crayfish production and the market supply surprised the scientific world.

It was then that the news came that the introduction of the crayfish de la Marismas was a plague and not a disease. This expression “crayfish plague” found scientific support and since then has been used in thousands of pages of newspapers, reports, edicts, laws: that the American crayfish is the culprit of the fungus. Truly the fungus does not survive outside the water, is asexual, in a tubular form, it only reproduces on the carapace of whatever crayfish species.

Nor was the signal crayfish brought from Simontorp, Sweden responsible for the fungus, unless we question the papers issued

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LEFT: *Procambarus* populations were captured with hoop nets in rice irrigation canals, rice fields and flooded areas of Coto Doñana National Park, adjacent to the famous pilgrimage village of El Rocío (pictured). Impacts from fishing activities within park lands were closely monitored by government agencies.

RIGHT: Because much of the well-drained private rice-growing region remained unirrigated during the winter, *Procambarus* fishermen focused on other areas that were undrained and flooded by winter rains adjacent to and in national parkland.

by LSU, the University of Lund or the Tetrapack laboratory. Signal crayfish are the inhabitants of waters of the river basins of Europe. The remarkable decrease of endemic crayfish in Spain was due to the change of agricultural implements, specifically the use of machinery in the fields, and from imports of the noble crayfish made from 1960 to 1965 from Germany.

The crayfish from Louisiana was introduced to end the rice monoculture and make better use of pumped water, amortize the construction of paddy fields and take advantage of the energy cost realized and paid by the landlords. Around 1975, fishermen of Isla Mayor activated their eel nets without any bait as in the country of their origin and placed them with the openings against the current. With their bicycles they crossed the long stretches of canals and captured crayfish. They delivered their live capture to the few processing centers, transforming the product into merchandise.

As yields of harvested crayfish increased from the rice-growing region of Andalucía, these animals were shipped to consuming markets within Spain. With remarkable speed, this new Spanish crayfish source effectively changed the trade deficit to one of Spain becoming a new exporter to France. By 1982, Spain was not only self-sufficient as an internal crayfish producer but began a profitable business of shipping surplus crayfish to French markets. This kept Spanish money at home and brought foreign capital into the economy.

The situation in the country had changed; it was no longer the good of the country but the interests of politicians. A discussion had arisen between the rice farmers and the fishermen. Rice farmers paid the energy costs and the fishermen made a profit with their effort. There was no judicial or political decision on the difference in the criteria. There was a legal vacuum and animals were not considered patentable. The Supreme Court decided that it was “public water in private channels” and the animals that live in the water have no owner.

It is interesting how such a small individual animal would arouse so much interest in written publications. There are about 7,500 works and articles in the press and on the Internet branded with the management of the crayfish from the Marismas and the Californian or signal crayfish *Pacifastacus leniusculus* as the culprit of decimation of the European species. When syphilis arrived in Europe, it was always referred to with reference to the enemy

country: in Spain it was the French disease, in Germany the Italian disease, in Italy the Spanish disease. We call the fungi “crayfish plague” as though the animal is guilty of the zoospore brought from America into Europe in 1850.

Among the many published studies there are three that express some hope of a resistance of some individuals of European species, or, the fungus itself has permuted. Now we speak of an As strain and a PsI strain of the genotype of the fungus, the PsI variety being more deadly than the As variety. But all the studies confirm until now the non-coexistence of fungus with the European species of crayfish.

But more surprising are the studies carried out by the University of Geneva that ask: are non-native species also an enrichment of biodiversity such as peanuts, corn, potatoes, sunflower, and cacao? A non-native species can provide a valuable food source for other organisms. Non-native species can fill a role in areas where it reaches a point of no return of a native species susceptible to an epidemic invader. Non-native species like the American species of crayfish can be a catalyst for restoration of *Astacus astacus* and other European species. Non-native species can reestablish a native species or substitute an existing ecosystem engineer like the bottom cleaner crayfish.

Procambarus clarkii has the approval of the directors of the wildlife reserve of Doñana because the crustacean supports 89 percent of the fauna that lives there thanks to the presence of the crayfish de la Marismas. But here we do not talk about species, we talk about people: 70 percent of the population, some 6,000 people, make a living in some form from the crayfish of the Marismas. In addition, the species was introduced in the 1970s by the Central Administration as a measure to support employment in rural areas.

I finish with a quote from a book about crayfish in Spain from 78 years ago: *We think it is idle to state that Spain has not yet achieved a position in the Yearbook; but we estimate that if it develops with the enthusiasm that seems to be starting, it is not risky to predict that in the not too distant future it will conquer the position it must occupy, with the consequent benefit for the country's wealth.* We have achieved this effort with our ingenuity, work, production, transformation and sale of the crayfishes de las Marismas.



LEFT: During the early 1980s, some sanctioned experimental attempts were made to encourage winter *Procambarus* production in the fallow Spanish ricefields by re-flooding over the harvested rice stubble. Such winter reflooding is the normal protocol for *Procambarus* production in native Louisiana.

RIGHT: *Procambarus* buying stations in Las Marismas, like this one at Casa Alta belonging to the Grau family, quickly became locations where fishermen could convert captured crawfish into needed income for their families and engage in conversation about local conditions.

Notes

D. Andrés Salvador Habsburgo-Lorena, Archduke of Austria, Honorary President of the Institucion de Investigacion y Ciencia de Carlomagno

Recently, Don Andrés was recognized by several organization in Andalusia, Spain for his contributions to the formation of an active and profitable *Procambarus* crayfish industry in Spain. Academic and municipal leaders awarded him with recognitions

and initiatives that noted his role in the historic introduction of this crustacean while he was a government agency administrator for freshwater fisheries over 40 years ago. This article is based on his address during a ceremony in his honor.

Submission of this article was initiated and facilitated by Albert P. “Rusty” Gaude III, Associate Area Agent, LSU AgCenter, Jefferson, LA. He also provided all photographs and associated captions.



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