European lobster - *Homarus gammarus*

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Biology, ecology and genetics

Distribution and capture

The European lobster, *Homarus gammarus,* has a broad geographical distribution (Fig.1). In its northern range, it occurs from the Lofoten Islands in Northern Norway to south-eastern Sweden and Denmark, but is absent in the Baltic Sea probably due to lowered salinity and temperature extremes. Its distribution southwards extends along the mainland European coast around Britain and Ireland, to a southern limit of about 30° north latitude on the Atlantic coast of Morocco. The species also extends, though less abundantly, throughout the coastal and island areas of the Mediterranean Sea and has been reported from the westernmost end of the Black Sea in the Straits of Bosporus (1, 2).

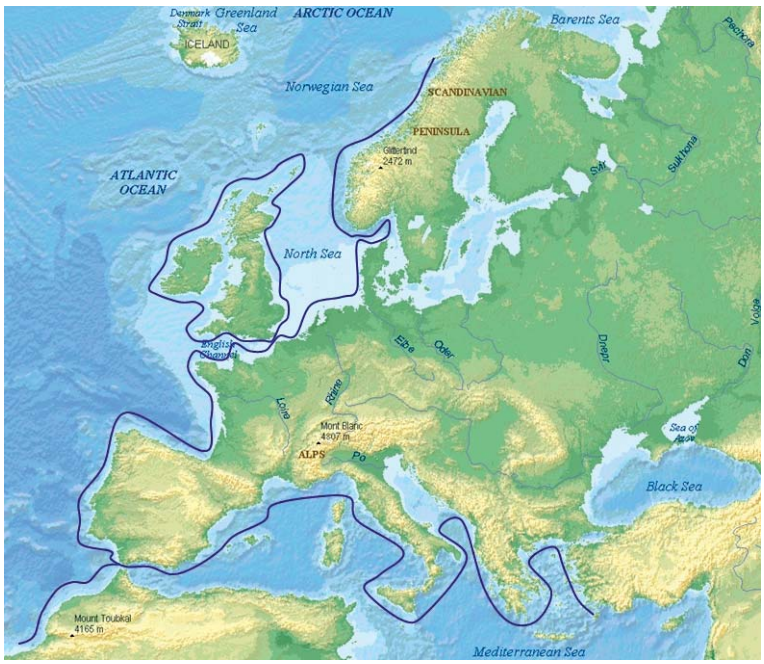

Fig. 1. *Geographical distribution of* H. gammarus

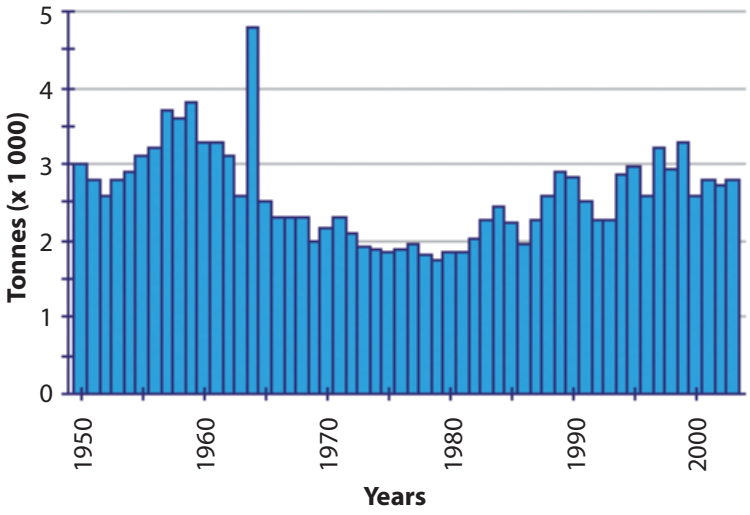

Fig. 2. *Total European capture production for* H. gammarus *(3)*

Capture

Within the past 70 years, total annual European landings have varied between 1 600 and 4 800 tonnes (Fig. 2). In the early 1960s, annual catches topping 3 000 -3 500 tonnes were not uncommon, but landings decreased during the 1970s to below 2 000 tonnes in the early 1980's. Since then, a slow increase to 3 200 tonnes has been observed. Lobster catches vary considerably between countries: between 1950 and 1975, Scotland accounted for 26% of total landings; Norway for 18%, followed by England, Wales and France with 16%, Ireland with 9% and Sweden, Denmark and Spain with less than 5% (4). Prior to the 1960s, Norway recorded annual catches ranging from 600 to 1 000 tonnes, but during the subsequent two decades a collapse in the fishery was observed and annual catches are now less than 30 tonnes. Within the Mediterranean countries annual reported landings have never reached the same levels as those seen in the northern distribution range (5).

European lobster fisheries have so far been either unregulated, or only lightly regulated by national minimum legal size, supported in some countries by national or local prohibitions on landing egg-bearing females and/or closed seasons. However, these have become more comprehensive in recent years to include V-notch schemes for berried females and nursery areas. From January 1st, 2002, a new EU minimum legal size of 87mm CL came into force which is broadly equivalent to the mean size of first maturity but this varies from area to area throughout the range (6).

Biology

European lobsters are usually located at lower than mean low water neaps (sublittoral fringe) to depths of 150m (2, 7). They are primarily nocturnal animals feeding on blue mussels, hermit crabs and polychaetes. Growth is by moult, which decreases in frequency during the juvenile stages until becoming an annual part of the mating, spawning and egg hatching cycle (8). Females can spawn annually or following a bi-annual pattern. Reproduction takes place during summer and is linked with the moulting cycle (9). After extrusion, the eggs are held on the pleopods for approximately another year until hatching the following summer. Large females (>120 mm carapace length) have been shown to moult and then undergo two successive spawns before moulting again, suggesting the capacity for sperm storage (10).

The first few post-hatching weeks are characterised by a pelagic phase usually lasting 14–20 days depending on the water temperature. During this period, larvae undergo four developmental stages until metamorphosis to stage IV (meta-larvae) when they settle to the seabed (11, 12). Despite significant and widespread investigations (13), no information is currently available on the early benthic phase (EBP) of the European lobster from settlement at 5-7mm CL until 20mm+ and juveniles are scarce up to 40-45mm CL. Thus, unlike what is common practice for the American lobster (*H. americanus*), it is not feasible to use EBP or early juveniles to predict future recruitment in *H. gammarus*.

In most areas lobsters do not mature before 5–8 years (depending on water temperature). Genetic data suggest that females in the wild mate with a single male (5). Results from tank experiments demonstrate that individual males can fertilise several females in the same season and this is likely to be the case in the wild. Thus the normal breeding system in the wild is likely to be polygynous (5). In the absence of exploitation the life span is probably in decade. Males reach sexual maturity earlier than females. European lobsters are sedentary animals with home ranges varying from 2 to 10km (14, 15, 16).

Population genetics

As result of the GEL-FAIR (Genetics of the European Lobster) project, the population genetic structure of the European lobster is now better understood in comparison to other marine species. Using a combination of molecular markers (microsatellites, mitochondrial DNA and allozymes) and a comprehensive sampling design involving over 5 000 individuals from 46 locations covering the whole distribution range of the species in Europe, researchers involved in the GEL project reported on an overall low level of genetic differentiation among population samples (5, 17, 18). There was no major evidence for great genetic discontinuities between the Atlantic and the Mediterranean populations in contrast to what has been demonstrated for some other marine organisms. All molecular markers corroborate the existence of four major distinct groups: northern Norway (19); Netherlands; remaining Atlantic samples; and the Mediterranean, in particular the Aegean (17). The northern Norway, Netherlands and Aegean groups differentiate from the main Atlantic group due to reduced gene diversity. Within the major Atlantic group, no correlation was found between geographic and genetic distance. Overall, results from the GEL project indicate that the European lobster is comprised of a large number of discrete populations with limited gene interchange among them (i.e. following an island model of population structure). Although the overall level of genetic differentiation among European lobster populations is low, this does not mean that there are not important adaptive genetic differences present. Indeed, it is extremely likely that lobsters living at the edges of environmental tolerance for the species are adapted to some degree to these conditions. Certainly life cycle parameters are very different in northern Norway and the Aegean (5, 17, 19).

Breeding and culture practices

Production

Lobster aquaculture production, although small, is growing. This trend is being driven by both a noticeable decline in fisheries in parts of the range, and an increased worldwide market demand for lobsters, with *H. gammarus* topping the list as one of the most desirable species.

Hatchery practices

In comparison to other lobster species, *Homarus* species are characterised by a simple and abbreviated larval period. They readily feed on natural and artificial food, are resistant to diseases and exhibit rapid and accelerated growth in warmed waters (20). Temperature is the primary controller of growth, with optimum water temperature around 20-22°C (21, 22). Larval period in 20°C water is around 12 days (23) in comparison to 35 days at 15°C (22). *H. gammarus* can reach 250-300g (total length 210mm, carapace length 75mm) in 24-30 months at 20°C constant water temperature (24). The main factors influencing growth rate in lobsters include handling, stocking density, habitat size, social interactions and water quality (21). Due to the considerable variation in individual growth rate and high losses due to cannibalism and associated injuries when kept in a communal system, cultured lobsters often have to be maintained in separate containers.

Fig. 3. *Juvenile lobsters at the Norwegian Lobster Farm at Kvitsøy, Norway (photo by E. Farestveit).*

Grow-out and restocking programmes

Lobster aquaculture can be carried out in three distinct forms: *product enhancement*, *resource enhancement* and *full grow out*. The latter two practices have been the focus of intensive research over the past 15 years. In *product enhancement*, wild caught lobsters are maintained in pounds where they are fed to improve quality/size (23). In r*esource enhancement aquaculture*, lobster hatcheries are built aiming at hatching eggs, and releasing stage I or stage IV larvae to supplement wild stocks (25). Magnetic binary-coded tags (microtags) and, more recently, genetic tagging allow for the quantitative evaluation of lobster release programmes (5, 26, 27, 28, 29). *Full grow-out*, or close cycle culture, is carried out independently of fishery and involves rearing lobsters from egg to marked size. Until recently, full grow-out culture of lobsters was not considered economically viable given the logistical implications related to the need to keep individual lobsters in separate compartments due to the cannibalistic behaviour and the lack of automated procedures for feeding and maintenance. These problems, however, have been recently addressed. A successful and comprehensive research project focusing on the development of methods for intensive farming of *H. gammarus* in closed system was recently reported (20). In optimal rearing conditions, it is possible to rear a portion size lobster from hatching in 800-900 days (30).

Although intensive culture does increase the likelihood for disease outbreaks, with over a century of experimental and commercial lobster hatchery operations, only few incidents of disease have been recorded (20, 31). Among the causes contributing to disease outbreaks are: excessively high temperatures, possible physiological stressors, poor water quality and inadequate nutrition (23). Disease is best avoided in aquaculture systems through preventive action (e.g. broodstock should be quarantined before being introduced into the hatchery) and a rigorous control over the key water quality parameters (20).

Interaction studies

During the last decades, there has been increasing awareness that aquaculture activities, including stock enhancement and commercial ranching, may have negative impacts on native gene pools. Genetic problems connected to hatchery operations (32) have been discussed in detail, and several recommendations are available (33). The main aim of domestication and selective breeding is to develop high performance strains under farming conditions. This unavoidably results in genetic changes in domesticated stocks. The main genetic concern is that interbreeding between wild and escaped farmed individuals or deliberate releases in enhancement/ranching could result in genetic changes in the wild populations resulting in reduced overall fitness and productivity (7).

In addition to commercial movements between countries, culture of lobster during the early high-mortality stages and then release in the wild has been widely practised as a means of potential enhancement of lobster stocks (29). However, in many cases marking of released individuals has not been carried out to determine the efficacy of the procedure. Where coded-wire or other physical tagging has taken place, this has been limited by the need to rear larvae to sufficient size and by cost, tag loss, etc (29). Furthermore, no account has been taken of the potential genetic changes in native stocks as a result of use of non-native lobsters in ranching or of commercial movements.

Genetic tagging is a viable and powerful approach to address these questions. Until recently, no adequate tools were available for genetic studies in *H. gammarus*. However, microsatellite and mtDNA markers that allow for high resolution genetic studies in this species, including genetic tagging, have now been reported (5). More recently, the genetic fitness of larvae from wild and ranched families was assessed using microsatellite DNA profiling (18). The authors found that the offspring of cultured females displayed relative fitness of 60% in relation to those of wild individuals clearly demonstrating the potential problems of cultured individuals at least during early larval stages (34). It is clear that additional research in this area is required.

European lobster management should be based on local populations i.e. self-recruiting stocks rather than on broader metapopulations as recently favoured by fisheries ecologists. Delimitation of a local stock is not straightforward and is likely to vary throughout the range. Assessment needs to be based on a combination of biological, hydrographical and genetic information. In many European countries wild lobster stocks are at very low levels. Given the information currently available, it would be wise to apply the precautionary principle to movements of lobsters for enhancement purposes. Transplantation of lobster stocks over larger distances should be avoided until much more detailed information on fitness related differences is available. However, the low level of gene flow suggests that lobster culture can be carried out in areas where there are no native populations without adverse impact on adjacent native stocks (5).

Conclusions/Implications

It is of crucial importance to investigate what possible effects domesticated stocks will have on wild populations, particularly for survival and other fitness traits. Furthermore, breeding experiments and genetic studies should be given high priority to increase our knowledge about quantitative genetics in European lobster.

Incidentally, the European lobster is an ideal model species for studying local adaptation. It occurs in a wide range of environmental conditions and produces large numbers of offspring. Since it is relatively easy to transport living females with attached fertilised eggs, it is possible to examine survival and other fitness traits of individuals from two populations under reciprocal environmental conditions. Such movement is at best extremely difficult for fish and many other marine organisms (5).

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