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A review of the alien serpulid and spirorbid Polychaetes in the British Isles

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Abstract : Four alien serpulids (*Ficopomatus enigmaticus, Hydroides elegans, H. dianthus, H. ezoensis*) and two alien spirorbids (*Janua brasiliensis, Pileolaria berkeleyana*) are reviewed and examples of serpulid nuisances are quoted. *F. enigmaticus* has been established in southern Britain since the 1920s and *H. elegans* was first recorded in the 1930s. *H. dianthus* was recorded for the first time in 1970, but it is suggested that it might have arrived in Britain at a much earlier date together with *Crassostrea virginica* from the eastern coast of North America. This oyster, frequently imported and relaid on British oyster beds before 1939 (but never successfully established), was the vector of introduction of various other alien species including the well-known gastropod oyster-pests *Crepidula fornicata* and *Urosalpinx cinerea*. The far-eastern *H. ezoensis* arrived as recently as the late 1970s. Although it had been observed a few years earlier on Japanese oysters (*Crassostrea gigas*) relaid on oyster beds in France, it more likely invaded Britain through ship-borne adults from Japan rather than through the agency of planktonic larvae drifting over from France where its introduction was possibly unsuccessful. In the event it could now reinvade and colonize the French coast through ship-borne adults carried across the Channel from England. *J. brasiliensis* and *P. berkeleyana* were first observed in 1974 in the course of an extensive study of the alien alga *Sargassum muticum*, but whether they had arrived in association with it, remains conjectural.

Résumé : Revue des Polychètes Serpulidae et Spirorbidae d'origine exotique dans les îles Britanniques. Les cas de quatre espèces de Serpulidae (*Ficopomatus enigmaticus, Hydroides elegans, H. dianthus , H. ezoensis*) et de deux espèces de Spirorbidae (*Janua brasiliensis, Pileolaria berkeleyana*) sont examinés et des exemples de nuisances par des Serpulidae sont évoqués. *F. enigmaticus* est établi dans le sud de l'Angleterre depuis les années 1920. *H. elegans* y fut trouvé dès les années 1930. La première récolte de *H. dianthus* date de 1970, mais on peut supposer que cette espèce a pu arriver en Angleterre à une date bien antérieure avec *Crassostrea virginica*, en provenance de la côte-est d'Amérique du Nord. Malgré les importations fréquentes et l'installation dans les parcs à huîtres en Angleterre, avant 1939, cette huître ne s'y est jamais établie avec succès. Elle a néanmoins servi de vecteur d'introduction à diverses espèces d'origine exotique, dont les Gastéropodes nuisibles aux huîtres bien connus, *Crepidula fornicata* et *Urosalpinx cinerea*. *H. ezoensis* est arrivé à la fin des années 1970. Quelques années plus tôt, cette espèce avait été observée sur des huîtres japonaises (*Crassostrea gigas*) installées dans des parcs à huîtres en France. Mais il paraît maintenant plus probable que *H. ezoensis* ait pu envahir l'Angleterre à partir d'adultes apportés du Japon par des bateaux que par la dérive de larves planctoniques à travers la Manche en provenance de France, où l'espèce ne semble pas s'être maintenue après sa première apparition. Elle pourrait maintenant revenir sur la côte française et la coloniser à partir d'individus adultes transportés à travers la Manche en provenance d'Angleterre. *J. brasiliensis* et *P. berkeleyana* ont été découverts en 1974 au cours d'une étude détaillée de l'algue exotique *Sargassum muticum*, mais leur arrivée conjointe avec cette algue reste hypothétique.

INTRODUCTION

While the term exotic or alien species might be applicable to any marine organism recorded far from its usual habitat, perhaps even one-off observations, the term introduced species, suggested by Carlton (1975) is more appropriate for those species transported from coast to coast, ocean to ocean, appropriate for those species transported from coast to coast, ocean to ocean, through Man's activities and which subsequently become established by maintaining a reproducing population.

Carlton (1975) considered four possible avenues of introducing alien species : 1. Ship fouling ; 2. Ship ballast water ; 3. Shellfish imports and movements ; 4. Commercial bait and fresh seafood transport (packing materials, etc.). With the implementation of the Molluscan Shellfish (Control of Deposit) Order 1974 and the variation order of 1983, one must consider that 1 and 2 are presently the most likely avenues of introduction into British waters. Now largely eliminated, the other agencies of accidental introduction, especially 3, formerly had a stronger impact by "enriching" the British marine fauna and flora, the best known examples being oyster pests and the "Japanese seaweed".

With previously uncontrolled shellfish imports and movements along the coast of southern England, with the ports of Southampton and Portsmouth in the Solent area and a large number of small boat movements from foreign waters, particularly continental Europe, it is not surprising that introduced species feature prominently in the Solent fauna and flora (Thorp, 1980).

The appearance of the Pacific brown alga (phaeophycean) *Sargassum muticum* (Yendo) Fensholt on the English and continental coasts of the Channel, followed by its very successful spread along the continental European coasts (Farnham, 1980 ; Farnham *et al.*, 1981 ; Belsher *et al.*, 1985 ; Belsher & Pommelec, 1988), have considerably renewed interest in alien and introduced species. *S. muticum* may well have arrived in France along with Japanese oysters before it invaded British shores (Farnham *et al.*, 1980). Druehl (1973) had remarkably predicted the establishment of this seaweed as a result of the introduction of *Crassostrea gigas* into France.

The accidental introduction of various organisms epibiotic on Japanese oysters (Gruet *et al.*, 1976), most of which were possibly unsuccessful in establishing permanent populations in European waters, illustrates how shellfish introductions into France occurred, initially, without due consideration of possible complications. Criticisms of these importations (Andrews, 1980 ; Secretan, 1981), pointing especially to jointly introduced oyster pests, were only too fully justified and should be extended to the joint arrival of all other alien oragnisms.

The Serpulidae and Spirorbidae are closely related families of polychaete worms possessing calcareous tubes. These tubeworms settle on a great variety of substrates, from soft algae and seagrasses through more solid organic material (wood, ascidian mantles, etc.) and mineralized algal and animal structures (calcareous algae, coral skeletons, mollusc shells, etc.) to permanent rocks. Natural and man-made structures are accepted with equal readiness. Some serpulids in particular can be important as fouling species and dense aggregations may result in large growths ("reefs" for some authors) in the natural habitat or on man-made structures (Rullier, 1943, 1946 ; Tebble, 1953 ; Behrens, 1968 ; Bosence, 1979 ; Hove, 1979 ; Thorp *et al.*, 1987, etc.).

Transport of serpulids and spirorbids as part of the encrusting fauna of ships' hulls may have been the usual agency of introduction into new areas, but the epifauna of deliberately introduced commercial molluscs should also be considered as another source of alien serpulid and spirorbid species.

Alien serpulid species in Britain

Ficopomatus enigmaticus (Fauvel, 1923)

First noticed in northern France as an alien species in 1921 (Fauvel, 1923), this serpulid species was commonly known as *Mercierella enigmatica* prior to the revision by Hove & Weerdenburg (1978). In spite of whatsoever has been written about it, the origin of *F. enigmaticus* has not been satisfactorily elucidated ; an Australian origin seems not unlikely. Although it has invaded brackish waters in temperate zones throughout the world, *F. enigmaticus* has rarely become established in the tropics where a related species, *F. ushakovi* (Pillai, 1960), has frequently been mistaken for it as pointed out by Hartmann-Schröder (1971), Zibrowius (1978) and Hove & Weerdenburg (1978).

In Britain *F. enigmaticus* was the first alien serpulid to be recognized and is now by far the best known alien serpulid species. According to Monro (1924) *F. enigmaticus* was present in the London Docks as early as 1922, almost contemporary to the first noticed population in northern France near Caen. Subsequently it has been recorded in various other localities in southern England, Wales and Ireland.

In 1937 it was reported from Weymouth Harbour, Dorset, blocking the sluice gates ; from there it invaded the adjacent freshwater Radipole Lake in 1952 when the sluice gates were kept open for some time (Tebble, 1953, 1956). Other localities mentioned in the literature are : Plymouth, Devon (Chelson Meadows, as early as 1939 ; Tebble, 1953 ; Gee, 1963) ; Shoreham Harbour Canal, West Sussex (Tebble, 1953) ; Cardiff Harbour, South Glamorgan and Portishead Harbour, Avon (Tebble, 1953 ; Gee, 1963) ; Swansea, West Glamorgan (Queen's Dock, as early as 1957 ; Naylor, 1957, 1959, 1965a, 1965b ; Bullimore *et al.*, 1978) ; Barrow-in-Furness, Cumbria (Cavendish Dock, in 1959 ; Markowski, 1962) ; Dale, Dyfed (Pickleridge Lagoon ; Gee, 1963) ; Milford Dock, Dyfed and adjoining waters (Nelson-Smith & Gee, 1966) ; Porlock Weir, Somerset (in 1968 ; Harris, 1970) ; Dover, Kent (J.D. George in Kilty & Guiry, 1973) ; Cork Harbour, southern Ireland (Kilty & Guiry, 1973) ; Abereiddy Quarry, Dyfed (Hiscock & Hoare, 1975) ; Chichester Harbour, West Sussex (in 1974 ; Thorp, 1980) ; Greenhithe, Kent, on the south side of the Thames estuary (in 1975 ; Dixon, 1981) ; Southampton Docks, Hampshire (Thorp *et al.*, 1987) ; Emsworth, West Sussex (Slipper Millpond in 1981 ; Thorp, 1987). In addition, various physiological studies refer to material collected at Weymouth Harbour and Greenhithe (above).

F. enigmaticus is most noticeable when it reaches epidemic numbers and indeed it was relatively large numbers, in the form of characteristic globular aggregations, that revealed its presence in the Slipper Millpond at Emsworth, West Sussex in 1981 (Thorp, 1987). Similarly, W.F. Farnham (pers. comm.) observed prolific populations in Weymouth Harbour in 1984, a locality where it was known to occur as early as 1937.

In the British Isles, *F. enigmaticus* is most commonly recorded on southern coasts, which suggests that it may be living close to its temperature minimum for maintaining populations and may be affected by particularly low winter temperatures. In the Slipper Millpond at Emsworth, the worms within the aggregates became quite inactive in the colder months of

the winters of 1981/82 and 1982/83, retreating to the lowermost regions of their tubes and accumulating considerable debris on their opercula. When removed from their tubes at this time, the worms (with the branchial filaments much reduced in length) initially remained inactive but when the temperature was raised over a few days to room temperature they resumed normal activity (Thorp, unpublished).

Hydroides elegans (Haswell, 1883)

H. elegans is widespread in harbour-fouling communities from the tropical to the warm temperate zones and also features prominently as a ship fouler but its precise centre of origin is unknown (Zibrowius, 1971, 1973, 1978 ; Hove, 1974). In the past, *H. elegans* has frequently been confused with *Hydroides norvegica* Gunnerus, 1768, a species indigenous to the northeastern Atlantic and the Mediterranean. In addition to opercular differences between *H. elegans and H. norvegica*, there are also differences in the collar setae (Zibrowius, 1971 ; Hove, 1974) and the composition of the calcareous tube : that of *H. elegans* contains aragonite as welle as calcite whereas that of *H. norvegica* has calcite only (Bornhold & Milliman, 1973).

In Britain *H. elegans* was recorded for the first time in 1937 in the now defunct Shoreham Harbour Canal (West Sussex) and was described by Monro (1938) as a new species, *Hydroides incrustans*, to distinguish it from *H. norvegica*. The Shoreham site was close to the warmed outflow from the power station. Subsequently the species was recorded from Swansea, initially as "*H. norvegica*" (Naylor, 1957, 1959) and later as *H. incrustans* (Gee, 1963 ; Naylor, 1965 a, 1965 b ; Bullimore *et al.*, 1978).

It can also be assumed that a temporary population of *H. elegans* settled in Ramsgate Harbour (Kent), which was able to reproduce. Newell (1954) reported a dense growth of "*H. norvegica*" (most of the tubes containing live worms) on the bottom of a boat brought to Whitstable (Kent) from Ramsgate. Subsequent re-examination of preserved samples (Bristish Museum, Natural History, cat. n°. 1953.2.1.2/5) proved them to be *H. elegans*.

Ramsgate Harbour was a small and unimportant harbour in the early 1950s and appeared to be unaffected by the warmed effluent from the power station, discharged into the estuary of the River Stour some 3.5-4 miles away across Pegwell Bay. Even at low tide, when the River Stour discharges through a distinct channel through the extensive sandflats to Pegwell Bay and the point of discharge of the river is only 1.5 miles south of east from the entrance to Ramsgate Harbour, it probably did not affect the basin. It is more likely that *H. elegans* was favoured in Ramsgate Harbour by the fact that the inner basin is separated from the outer Royal Harbour by lock gates. The water retained within the basin could become heated above ambient on hot summer days, encouraging reproduction, but the influence of the continental winter on the south-east shores of Britain would probably make it difficult for *H. elegans* to survive the low winter temparatures.

In Britain, *H. elegans* appears to favour sites where the water temperature has been raised artificially. In the Netherlands it has been found to occur under similar conditions (Hove, 1974).

Hydroides dianthus (Verrill, 1873)

Previously identified in European waters by Zibrowius (1971) as an alien, having its origin along the eastern coast of North America (Maine to Gulf of Mexico), *H. dianthus* is the third alien serpulid species to be known from Britain. It was reported by Zibrowius (1978) from a single specimen obtained in 1970 at Hamble Spit, an intertidal mudflat on the eastern shore of Southampton Water (collector J.D. George ; specimen deposited at the British Museum, Natural History, cat. n°. 1971 ; 219) : this record was missing from Thorp's (1980) list of alien species in the Solent area. More recently *H. dianthus* has been recorded in small numbers amongst encrustations of *Hydroides ezoensis* on harbour structures in Southampton Docks (Thorp *et al.*, 1987). Although this species is known from British waters from only a few specimens, and is apparently confined to Southampton Water, it is of particular interest for various reasons.

While permanent, large scale colonizations by *Ficopomatus enigmaticus* and *Hydroides elegans* cannot be expected around the coasts of Britain, on account of their apparent temperature tolerances, the same need not be so for *H. dianthus*. In fact, this species experiences similar conditions in Britain to those prevailing throughout large parts of its native habitat on the eastern coasts of North America where it is common in marine and estuarine conditions. Accordingly it can be expected to spread, as it has already done in the Mediterranean, where it was first collected in the 1860s, a few years before Verrill described it from Massachusetts. Despite its early introduction it remains characterized in the Mediterranean by a disjunct distribution comprising harbours and brackish lagoons (localities now recognized to be more numerous than those known to Zibrowius, 1971, 1973, 1978).

Zibrowius (1971) suggested that *H. dianthus* could have been transported from North America as part of the encrusting fauna of ships' hulls ; indeed its early presence in the Mediterranean and its spread to many Mediterranean harbours and lagoons may best be explained by shipping being the main vector of dispersal.

While *H. dianthus* could have arrived through the agency of shipping, its presence in Britain and on the Atlantic coasts of France and Spain suggests an additional/alternative agency for the invasion of European waters (Zibrowius, 1983b). This serpulid could have reached these shores as part of the epifauna of the American oyster *Crassostrea virginica* (Gmelin). *C. virginica* has a similar, if slightly more extensive, distribution on the Atlantic seaboard of North and Central America (from the Gulf of St. Lawrence to Panama).

From 1861 to 1939, *C. virginica* was repeatedly imported into British and Irish waters and relaid on the oyster beds to supplement the larger summer market demand, rather than to establish a more permanent introduction (Ingersoll, 1887 ; Stevenson, 1899 ; Went, 1962 ; Tebble, 1966 ; Walford & Wicklund, 1973). *C. virginica* never became established in Britain and attempts to establish it in France (Arcachon basin ; Fischer, 1864, 1865) and Denmark (Arø Island/Little Belt ; Möbius, 1883, 1885) were similarly unsuccessful.

C. virginica has already been recognized as the vector of introduction of two undesirable prosobranch gastropods, viz., *Crepidula fornicata* Linnaeus, 1758, and *Urosalpinx cinerea* (Say, 1822), the former a filter feeder competing with oysters for both food and space, the latter a predator (oyster drill) killing large numbers of young oysters. *C. fornicata* arrived as early as 1870, approximately, whereas the first specimens of *U. cinerea* were collected in 1920. The literature on these imported gastropod oyster pests in Britain and elsewhere in Europe is abundant, and frequently refers to their accidental arrival as a result of the early importations of *C. virginica* (Cole, 1952 ; Hancock, 1959 ; Franklin & Pickett, 1974, etc.). In European waters both species of gastropod oyster pests are no longer limited to the British Isles. *C. fornicata* has colonized the coasts of Denmark, Germany, the Netherlands, Belgium and France where, by the mid-1970s, it had extended its southern limit south of the Arcachon area, while *U. cinerea*, although less widely distributed, has also been identified in the French oyster centres of Brest and Arcachon.

Other western Atlantic species introduced into European waters, and so far identified only from the oyster grounds of southern England (where the importations of *C. virginica* were concentrated) include the maldanid polychaete *Clymenella torquata* (Leidy, 1855) (Newell, 1949a, 1949b, 1954) and the ostracod *Sarsiella zostericola* Cushman, 1906 (Kornicker, 1975 ; Bamber, 1986, 1987).

The relatively recent first record of *H. dianthus* in Britain does not necessarily preclude its much earlier arrival, possibly coincident with that of *Crepidula fornicata* and *Urosalpinx cinerea*. Despite its apparent small numbers, *H. dianthus* may be quite widespread in British waters but largely unrecognized. It should be remembered that the identification of *H. dianthus* from European waters occurred some 100 and 50 years after the first samples had been collected from the Mediterranean and the Bay of Biscay, respectively (Zibrowius, 1971).

Hydroides ezoensis Okuda, 1934

H. ezoensis is well known throughout the Japanese Islands and has also been recorded from the Soviet coast of the Sea of Japan and the east coast of China (for references see Zibrowius, 1978 ; Thorp *et al.*, 1987). It was recognized in Europe for the first time in 1973 as part of the epifauna associated with the oyster *Crassostrea gigas* (Thunberg, 1793) imported from Japan and relaid on the oyster beds of the Atlantic coast of France (Gruet *et al.*, 1976 ; Zibrowius, 1978). *H. ezoensis* easily survived the symbolic, rather than effective, measures taken to prevent the introduction of undesirable accompanying organisms - a short immersion in fresh water - and large specimens of *H. ezoensis* were recovered with the oysters after one year on the oyster beds.

When large encrustations of *H. ezoensis* were identified from ships' hulls (tugs) and man-made structures along the length of Southampton Water (Fawley Power Station, the Hamble marinas and the many quays of Southampton Docks) in 1982 (Thorp *et al.*, 1987), it was initially assumed that they could have originated from established populations on the French coasts.

Large numbers of *C. gigas* were introduced from Japan directly into various sites on the Atlantic, Channel and Mediterranean coasts of France and indirectly by relaying from established populations on the Atlantic coast (Maurin & Le Dantec, 1979). If established on the Channel coast (where the oyster had been introduced in the Gulf of St. Malo), "invasion" of southern British shores would have been a simple process by planktonic drift of larvae or the carriage of settled adults on cross-channel ferries and numerous private boats. However, as briefly reported by Thorp *et al.* (1987), an extensive investigation of ports, marinas and oyster parks on the Atlantic and Channel coasts of France, from the Caen area in the north to Arcachon in the south in the summer of 1986, failed to reveal any specimens of *H. ezoensis*.

As Thorp *et al.* (1987) report, the presence of *H. ezoensis* in Southampton Water can be traced back to at least 1976 when a single small adult was surprisingly taken in a plankton tow in the seawater intake channel of Fawley Power Station. While there is a remote possibility that a 1976 or earlier "invasion" of the Solent had its origin on the French Atlantic coast, where adults were reported in 1974 (Zibrowius, 1978), it is more likely that the large number of Japanese ship movements into the port of Southampton comprised the effective vector of introduction of adults either on ships' hulls or within ballast tanks.

With such massive populations in Southampton Water one would have expected a rapid spread of *H. ezoensis* on British shores. Outside Southampton Water, however, there has as yet been little colonization of Solent waters in general (Thorp *et al.*, 1987) apart from a relatively modest population at Cowes, Isle of Wight. A large population transferred to Brighton Marina, East Sussex, in 1984 as fouling on the hull of H.M.S. Cavalier not only failed to reproduce but also deteriorated rapidly and much of the fouling had dropped off the hull by mid-1986.

An extensive search of other ports in mainland Britain, particularly those receiving Japanese shipping, has failed to record *H. ezoensis* elsewhere (Thorp *et al.*, 1987).

Finally, we should perhaps consider the possible introduction of *H. ezoensis* together with *Styela clava* Herdman, 1882 (= *S. mammiculata* Carlisle, 1954), a far-eastern ascidian introduced in the 1950s to Plymouth, Devon, and subsequently recorded elsewhere in England, and also in Ireland, Denmark, the Netherlands, France (Channel and Arcachon) and northwestern Spain. That *H. ezoensis* has only exhibited an explosive colonization in the Solent region in recent years, however, argues strongly against this possibility.

Alien spirorbid species in Britain

Two alien spirorbids have been known from Britain since 1974, collected together in Portsmouth Harbour and associated with *Sargassum muticum* (Knight-Jones *et al.*, 1975 ; Knight-Jones & Knight-Jones, 1977 ; Thorp, 1980 ; Thorp *et al.*, 1986) : *Janua (Dexiospira) brasiliensis* (Grube, 1872) and *Pileolaria (Pileolaria) berkeleyana* (Rioja, 1942) (= *P. rosepigmentata* Uchida, 1971).

Whether one or both species arrived in association with *S. muticum* remains a matter of conjecture. While both species were recorded as a consequence of intensive studies of

Sargassum, there is no certainty that such small organisms were not present at an earlier date or alternatively arrived independently. For example *P. Berkeleyana* was first recorded 3-4 months after a visit of two Japanese naval vessels to Portsmouth Harbour and *J. brasiliensis* a similar period after the finish in Portsmouth of a round the world yacht-race, the last point of call being Rio de Janeiro, Brazil.

J. brasiliensis is widespread (perhaps secondarily by the agency of shipping) from tropical to temperate areas, including Brazil (type locality : Desterro = Florianopolis) and Japan (where it had been described, independently, as *Dexiospira oshoroensis* Uchida, 1971). The limited distribution of *J. brasiliensis* in Britain (Portsmouth Harbour) suggests that it is a true alien. Susequently, *J. brasiliensis* has been recorded in association with both *Sargassum* and *Zostera*, in the Goes Canal (Ooster Schelde) in the south-west Netherlands - it probably arrived there as an epiphyte on drift fragments of *Sargassum* (Critchley & Thorp, 1985).

When first reported in Britain from Portsmouth Harbour as *P. rosepigmentata*, the other species was thought to occur only in Japan. It has since been identified from Monterey, California, USA (Knight-Jones *et al.*, 1979). More recently, Thorp *et al.* (1986) have acknowledged that *P. rosepigmentata* is synonymous with *P. berkeleyana*, originally described from the Pacific coast of Mexico (Acapulco), and that the species has a considerably greater distribution being recorded from all oceans except the Arctic (perhaps secondarily by the agency of shipping). In Britain it has also been recorded from both Plymouth, Devon, and Falmouth, Cornwall (Thorp *et al.*, 1986), and most recently a single specimen was identified on *Sargassum muticum* at St. Helier, Jersey (Critchley & Thorp, unpublished). The presence of *P. berkeleyana* in three south coast international ports and its absence from similar depths outside those ports, so reminiscent of its distribution around the ports of Marseille (Zibrowius & Bianchi, 1981 ; Zibrowius, 1983a, 1983b), suggests an alien status rather than an icomplete record of its British distribution.

The suggestion by Knight-Jones & Knight-Jones (1977) that *Paralaeospira malardi* Caullery & Mesnil, 1897, was possibly an earlier ship-borne immigrant from the southern hemisphere (where, in contrast to the northern hemisphere, the genus is well represented by various species) appears to be considerably more speculative.

DISCUSSION

Crisp (1958), in discussing the spread of the introduced antipodean barnacle, *Elminius modestus* Darwin, 1854, suggested two means of spread : 1. Marginal dispersal - where the local limits of a species are extended by planktonic larval dissemination ; 2. Remote dispersal - where new areas are colonized sufficiently far from an established centre of population to preclude larval drift. In such instances the vector of spread is most often Man through shipping movements, shellfish importation and movements, etc., i. e. the avenues also discussed by Carlton (1975) (see introduction).

The presence of most introduced species in harbours and estuaries not only supports shipping and shellfish movements as major vectors of introduction, but also ensures that subsequent generations are ideally situated to take advantage of these means of carriage to increase their range. This situation is well illustrated by the alien serpulids and spirorbids identified from British waters and potentially epibiotic on ship's hulls and oysters.

Among all these alien tubeworms, the serpulid *Hydroides elegans* appears the least adapted to permanent establishment because of its need of relatively high temperatures, generally to be found in Britain only in artificially heated systems (thermal pollution). In contrast, the local climate in Britain appears to present no problem for *Hydroides ezoensis*, which has demonstrated its capacity as a major fouling organism over several years already (Thorp *et al.*, 1977). Its previous arrival in France with Japanese oysters relaid on oyster beds (Gruet *et al.*, 1976 ; Zibrowius, 1978, 1983b) was apparently not a good starting point for successful marginal dispersal by larval drift. Given its very efficient settling capacity on ships' hulls in the more confined areas of the Solent, including marinas, it may now take advantage of cross-Channel ship movements for releasing larvae that will settle successfully in harbours of the French Channel coast.

Similar to the discovery and identification of *Sargassum muticum*, that of *Hydroides ezoensis* was made sufficiently early to enable any resultant changes to be monitored. However, this does not happen in all cases of accidental introductions. As suggested in the present paper, the alien *Hydroides dianthus* was possibly detected in Britain a long time after the initial introduction.

Being widely overlooked appears to be a not uncommon destiny of serpulids and spirorbids even in Britain where investigation of these tubeworms has an established tradition. In addition to the obvious aliens discussed in the present paper, three other serpulids have been recorded recently from southern Britain for the first time and from harbour environments (Thorp *et al.*, 1987) : *Vermiliopsis striaticeps* (Grube, 1862) from Falmouth Harbour, Cornwall ; *Metavermilia multicristata* (Philippi, 1844) and *Filogranula calyculata* (O. G. Costa 1861) from Abereiddy Quarry, Dyfed, South Wales, which is used as a small boat anchorage (previously not recorded there by Hiscok & Hoare, 1975).

Because the discovery of these species nearly coincided with that of the obvious alien *Hydroides ezoensis*, there was some vagueness in the paper (Thorp *et al.*, 1986) concerning the status of the three newly recorded species (alien or indigenous). As argued below, they should in fact be considered as indigenous to Britain, despite their occurrence in harbours far distant from the nearest previous collecting points.

Available data (Zibrowius, unpublished) show that these species are widespread in natural habitats in both the Mediterranean and the northeastern Atlantic, *V. striaticeps* only in shallow water, *M. multicristata* and *F. calyculata* from shallow to deep water. As early as 1950, *V. striaticeps* (misidentified by Cornet & Rullier, 1951, as *Vermiliopsis infudibulum*) had established a population in the aquarium of the Roscoff Marine Station (Brittany), having entered the tanks either as planktonic larvae with the continuous sea water flow, or as adults living on substrates collected from nearby waters. *M. multicristata* has been col-

lected in 1971 from deep-water in the Celtic Sea, in 1972 from a depth of 90 m in the Channel off Roscoff, and in 1975 from shallow water in the Gullmarfjord, west coast of Sweden. The new record of *F. calyculata* (Thorp *et al.*, 1986) appears more isolated from previous ones, the nearest record being from deep water in Setubal Canyon, Portugal, in 1957 ; however, it should be noted that this species, as the smallest one, is also the easiest to be overlooked. We can be confident that more extensive and detailed diving explorations would lead to the discovery of the more natural habitats of these three serpulid species newly recorded from Britain.

Occurrence in harbours does not preclude the possibility that species are native to the area considered. *V. striaticeps, M. multicristata* and *F. calyculata* have been obtained from the underside of stones and artificial substrates (such as tiles) in shallow water in Frioul Harbour of Marseille, northwestern Mediterranean, together with alien species such as *Spirorbis marioni* and *Pileolaria berkeleyana* (Zibrowius & Bianchi, 1971 ; Zibrowius, 1983b). In the Marseille area they occur elsewhere in various natural habitats, especially in submarine caves.

Various serpulids are known to cause considerable problems both as fouling organisms on harbour structures, ship hulls and in the seawater cooling systems of power stations and industrial plants, and also as competitors for both space and food on oyster beds. *Spirorbids* may contribute to heavy fouling but are not the major constituents because of their small size.

Occasionally, heavy fouling or competition may be caused by indigenous species. Thus *Pomatoceros triqueter* (Linnaeus, 1757) was found to be the main species in thick serpulid encrustations, which were remarkably chlorine-tolerant, in an industrial cooling system at Port-de-Bouc near Marseille, Mediterranean coast of France (Zibrowius & Bellan, 1969). Likewise, in Britain, *P. triqueter*, possibly confused with *Pomatoceros lamarckii* (Quatrefages, 1865), has been mentioned as competing with oyster spat for food and space (Cole, 1951). According to Nelson & Stauber (1940), *Hydroides dianthus* (quoted as *H. hexagonus*) may kill young oysters (*Crassostrea virginica*) by overgrowing them in its native area of eastern North America.

The most serious nuisance from serpulids, however, normally results from the excessive proliferation of alien species in new environments. The alien *Hydroides elegans* is the main fouling serpulid in Mediterranean harbours, where it is locally associated with other alien species, *Hydroides dianthus* and *H. dirampha* Mörch, 1863 (Zibrowius, 1971, 1973, 1978). It has also caused heavy encrustations in cooling systems, for example at Taranto, southern Italy (Parenzan, 1965 ; Paoletti & Sebastio, 1973) and at Corpus Christi, Texas (Behrens, 1968), in both cases incorrectly identified as "*Hydroides norvegica*". At Hiroshima, southern Japan, Arakawa (1971) ascribed the loss of 30 percent of oyster cultures to a mass proliferation of "*Hydroides norvegica*", presumably *H. elegans*.

In Britain *Ficopomatus enigmaticus* has become a major fouling nuisance in restricted localities as pointed out, notably, by Monro (1924) and Tebble (1953, 1956). Likewise, *Hydroides ezoensis*, the most recent serpulid addition to the British fauna, has already pro-

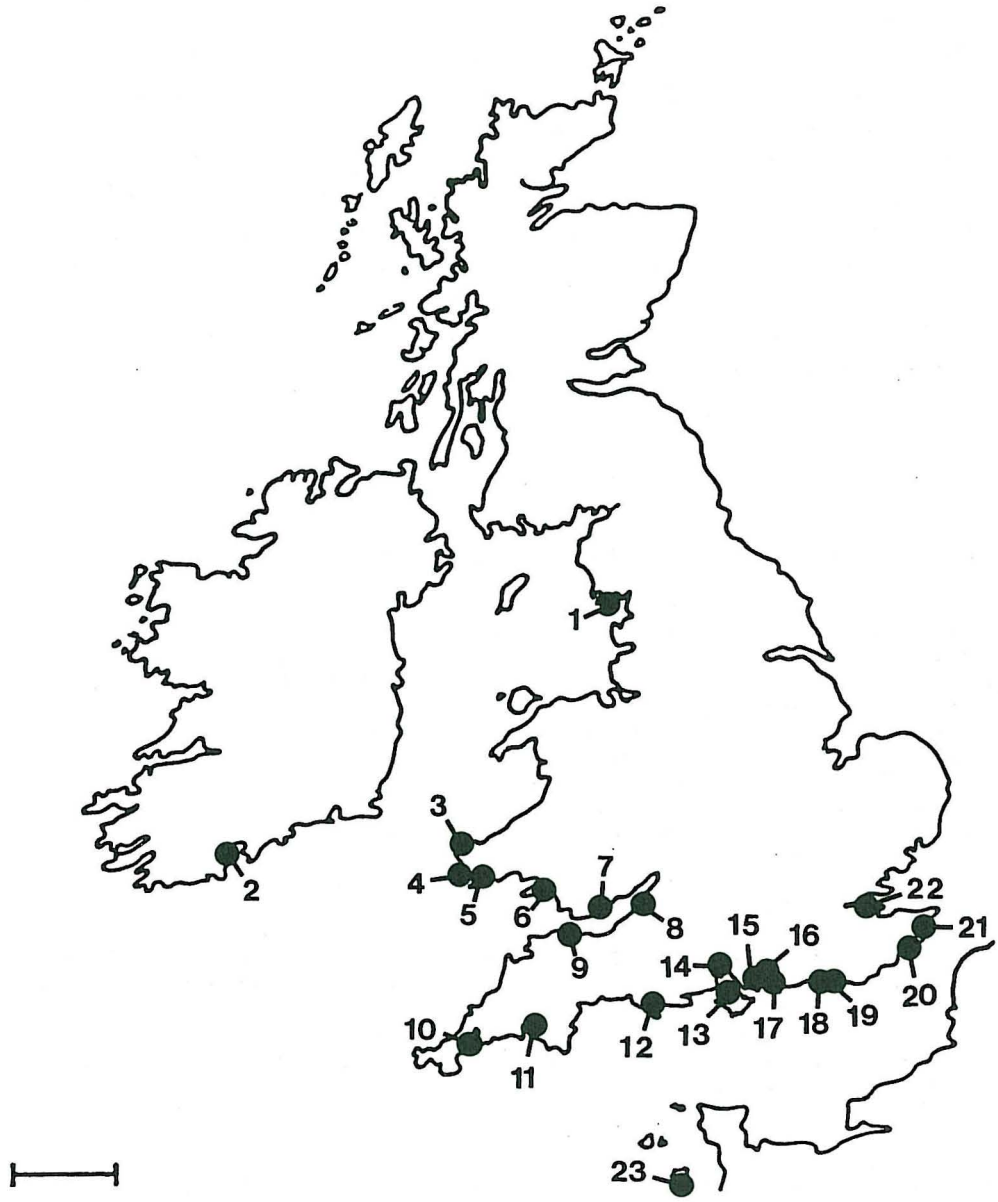

Fig. 1. : Map of the British Isles showing the localities where introduced serpulids and spirorbids have been recorded. 1. Barrow-in-Furness ; 2. Cork ; 3. Abereiddy ; 4. Dale ; 5. Milford Haven ; 6. Swansea ; 7. Cardiff ; 8. Portishead ; 9. Porlock ; 10. Falmouth ; 11. Plymouth ; 12. Weymouth ; 13. Cowes ; 14. Southampton ; 15. Portsmouth ; 16. Emsworth ; 17. Chichester ; 18. Shoreham ; 19. Brighton ; 20. Dover ; 21. Ramsgate ; 22. Greenhithe ; 23. St. Heleir. Scale bar = 100 km.

ved to be a mass colonizer and fouling organism (Thorp *et al.*, 1987) and can be expected to spread widely on British coasts and on the continental European coasts from its present centre of population in Southampton Water.

While mass settlement of *Hydroides dianthus* has not yet been observed in the British Isles, its present distribution and probable further extension should be monitored. Being the host of certain trematode stages (fish blood flukes) in eastern North America (Stunkard, 1970), it should be investigated with respect to its parasites.

The preceding examples should be regarded as warnings, emphasizing that further serpulid introductions, as part of the epifauna of commercial shellfish, should be avoided. Undesirable and massive proliferations of alien species in new environments can never be ruled out. The arrival of additional alien species transported on ships' hulls or within ballast water tanks may be an unavoidable possibility, but the number of potential invaders should not be increased through complementary agencies as a result of avoidable negligence.

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