

## The Status of the Twaite Shad, *Alosa agone*, in Italy and the Western Balkans

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With 7 figures and 5 tables

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**Abstract.** The twaite shad, *Alosa agone*, is still quite common in Italy and the western Balkans, but locally is endangered or extinct. Two eco-phenotypes are recognized: the migratory ‘Cheppia’ or ‘Laccia’ and the landlocked ‘Agone’. The two forms have never been in contact, at least in Italy. The migratory form is more endangered since barriers and dams prevent it from reaching upstream spawning grounds. A few reproductive communities are documented, e. g. in the Po River in Italy and Neretva River in Croatia. Resident stocks have increased to substantial populations in the large lakes of Italy, especially in the last ten years, probably as a result of improved water quality. The landlocked form from northern Italy was successfully introduced into lakes of central Italy about 75 years ago. In Sardinia a population derived from the migratory form was established about 80 years ago in the artificial Lake Omodeo. In Croatia the ‘Cheppia’ seems to live only in the lower course of the Neretva River. In Montenegro, ‘Cheppia’ and ‘Agone’ live in sympatry in Lake Skadar, but a dam built in 1960 caused a strong decline of both forms. The twaite shad is a very variable species, able to modify its morphology and biology according to its adaptation to freshwater or marine biotopes. In the Mediterranean area, only one taxon should be then recognized, *Alosa agone* (Scopoli, 1786). This will replace *Alosa fallax* (Lacépède, 1803), a taxon described from the Atlantic drainage area which seems to be distinct from Mediterranean populations. A survey of the distribution of reproductive communities of the migrating form in the Mediterranean area must be carried out.

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## Problem

The present distribution of reproductive communities and the conservation status of the twaite shad, *Alosa agone* (Scopoli, 1786), in central and eastern Mediterranean areas are still poorly known, especially in the eastern Adriatic drainage basins in Croatia, Montenegro, Albania and the Former Yugoslavian Republic of Macedonia (FYROM). This species, which is mainly amphibiotic, is able to form landlocked populations. The landlocked form is frequent in several lakes of northern Italy where, after a long period of progressive decline (Gandolfi *et al.*, 1991), it has now become reestablished, probably as result of improved water quality (Negri, 1993; Grimaldi, 1997; Confortini, 1998). In the eastern Adriatic drainages in Croatia, Montenegro, Albania and FYROM, the landlocked form is present in two or three lakes.

In the past, migratory populations were common in all coastal areas (Scotti, 1897; MAF, 1931; Ferrero, 1951; Vukovic, 1961; Tortonese, 1970; Ivanovic, 1973) and spawning occurred in the lower courses of medium- and large-sized rivers. Today the global situation of the migratory form, which has little commercial value, is poorly known since it is often not included as a distinct species in yearly fishing statistics. The species is very seldom if not extinct in the Ebro River, (B. Elvira, pers. comm.), the only western Mediterranean basin of the Iberian Peninsula where the species still exists (Elvira, 1995). In France, the populations of the amphibiotic form are now progressively increasing due to conservation measures and construction of fish ladders on dams, especially along the Rhône River (Le Corre *et al.*, 2000). In Greece, its presence is documented for at least four rivers: Evros, Nestos, Strymon and Pinnios (Bobori *et al.*, 2000), but no information is available about its conservation status, ecology and biology.

Recent data concerning the pan-Mediterranean distribution and conservation of the twaite shad are quite scarce (Baglinière, 2000). Thus a survey of the migration and population density of the species along the coast and lower course of rivers is needed.



Fig. 1. The study area with indications of main basins cited in the text; a) Lake Orta, b) Lake Maggiore, c) Lake Como, d) Lake Lugano, e) Lake Iseo, f) Lake Garda, g) River Po, h) Lake Bracciano, i) Lake Vico, l) River Tiber, m), Lake Omodeo, n) River Tirso, o) River Neretva, p) Lake Skadar, q) Lake Ohrid, r) River Evros, s) River Nestos, t) River Strymon, u) River Pinnios.

In this paper, I outline the status of *A. agone* in Italy and the western Balkans, where the species seems to be most frequent and most studied. The names of principal basins of the study area, discussed in the text, are reported in Fig. 1.

## Survey methods

I examined the old and recent literature on the local or general status of the genus *Alosa* in Italy and the western Balkans. Unpublished reports were also consulted, especially those concerning northern Italy. Several technical papers deal with the life history or fisheries because the landlocked form of *Alosa* is intensively fished and has local commercial value in that area. Little-known publications from the western Balkans (Montenegro, Croatia, FYROM) were also consulted and some local fishermen were interviewed.

For complementary analyses, I have also included morphological data of several samples of *Alosa* housed in my Department: a) 8 fishes from the Neretva basin, Croatia, collected by M. Mrakovcic in May 1994; b) 3 fishes from Lake Skadar, Montenegro, collected by the late B. Knezevic in June 1975; c) 10 specimens from the Adriatic coast near Pescara, central Italy, collected by G. Amazzalossi in June 2000; d) 2 specimens from Lake Omodeo in Sardinia, collected by P. Massidda in June 1999. Gill raker counts and measurements were made according to Holcik (1989). The results are reported in Table 1.

## Fluctuation and variation of the twaite shad in Italy and the western Balkans

Two ‘ecological forms’, sometimes regarded as subspecies, occur in fresh waters or seas of Italy and the western Balkans: the migratory form, known in the vernacular as ‘Cheppia’ or ‘Laccia’, and the landlocked form, called ‘Agone’. Both forms have been known since historical times. An interesting documentation of the history of these two forms is reported in the first extensive Italian ichthyological work published about four centuries ago (Salviani, 1554). According to this author, the distinction between the two forms was known since the ancient Greek and Roman periods. Salviani provided

Table 1. Mean measurements or range (expressed as thousandths of the Standard Length) and gill raker counts (standard deviation in parentheses) in two samples of the migratory form of twaite shad (Pescara and Neretva) and two variables lacustrine populations from Lakes Skadar and Omodeo.

| Locality      | n  | Standard length (mm) | Head length | Head depth | Body depth | Least depth | Scales on ventral keel | Gill rakers | Dorsal fin rays | Anal fin rays |
|---------------|----|----------------------|-------------|------------|------------|-------------|------------------------|-------------|-----------------|---------------|
| River Neretva | 8  | 265–340              | 265(5)      | 227(5)     | 261(10)    | 90(4)       | 38(1)                  | 35(2)       | 15(0)           | 20(1)         |
| Lake Skadar   | 3  | 235–324              | 238–244     | 176–186    | 248–259    | 73–79       | 35–36                  | 32–33       | 15              | 19–20         |
| River Pescara | 10 | 212–322              | 258(13)     | 209(9)     | 274(11)    | 89(4)       | 38(1)                  | 35(2)       | 15(0)           | 18(1)         |
| Lake Omodeo   | 2  | 226–227              | 240–256     | 176–192    | 247–251    | 79–83       | 36–38                  | 48–49       | 15–15           | 20–21         |

the first acceptable drawings of both forms. The marine migratory form was common in all Mediterranean drainage basins (Scotti, 1897), but it disappeared in dammed or blocked rivers. Today, few reproductive migratory populations remain in the Mediterranean (Baglinière, 2000), while the landlocked 'Agone' still forms substantial populations, especially in northern and central Italy.

### 1. Distribution and fluctuations of the migratory form

In Italy the migratory form is still quite common near the estuary and in the lower course of rivers. The shads usually enter the river mouth following the first spring flood, but the run stops just below the first dam where they remain until the end of the reproductive season, which is usually unsuccessful (Vitali *et al.*, 1983). In historical times, the migratory form was known to reach Milan in the Po River basin and, on the main course, the town of Casale about 400 km from the Po mouth (De Filippi, 1844; Pavese, 1896). The Isola Serafini dam has now been abandoned and several fish ladders allow the 'Cheppia' to run upstream again (G. Gandolfi, pers. Comm.). In Veneto, it used to reach the lakes near Mantua, the Adige and other large rivers of central and north-eastern Italy (Pomini, 1937; Gridelli, 1935). In the upper Adriatic river basins the species now occurs mainly along coastal areas and river mouths (Loro *et al.*, 1994; Marconato *et al.*, 1986; Maio & Turin, 1999). In central Italy, upstream migration occurred in all water courses, even for more than 100 km in major rivers. In the Tiber River the migratory form was able to reach Orvieto (Paglia River) and Todi, two classic spawning sites for this species about 210 km from the river mouth (D'Ancona, 1927). Today, upstream migration is prevented by a dam near Rome.

In Italy the migratory form has never come into contact with an established population of the landlocked form and has never entered Lakes Maggiore (Grimaldi, 1997), Como, Iseo (Negri, 1993) and Garda (Malfer, 1922). In Sardinia, migratory populations on the Tirso River became landlocked in several artificial lakes on the river, *i. e.* Lakes Omodeo, Castel Doria, Del Posada, Villanovatulo (Cottiglia, 1963a, 1968). However, the twaite shad has apparently disappeared due to dry seasons in recent years (P. Massidda, pers. comm.).

In Croatia the shad occurs along the coasts, but apparently only enters the River Neretva (Vukovic, 1961; Mrakovcic *et al.*, 1995). Landlocked migratory populations are known to exist in several artificial lakes (M. Mrakovcic, pers. comm.).

In Montenegro, Albania and FYROM, it is distributed along the Adriatic coast and enters at least the Drin River to spawn. In the past, it could migrate into Lake Skadar through the River Bojana and running populations were probably able to reach Lake Ohrid and Lake Bacinska (Tocko & Jovanovic, 1959; Vukovic & Ivanovic, 1971; Maric & Kazic, 1990; Maric, 1995). The species appeared in catches from Lake Skadar until 1987. Following construction of a dam on the Bojana River (the emissary of Lake Skadar) in the Albanian part of the basin, there was a drastic reduction of euryhaline species such as mugilids, acipenserids and shads. The shad rapidly decreased and disappeared, at least as a species included in fishing statistics (Stein *et al.*, 1981; Maric & Kazic, 1990). At present, the migratory form seems to be very rare in the lake (D. Maric, pers. Comm.).

## 2. Distribution and fluctuations of the landlocked form "Agone"

*Italy*: major lakes of northern regions (Lakes Maggiore, Lugano, Como, Iseo, Mergozzo, Garda). Stocked in lakes of central Italy (Lakes Bracciano, Vico, Bolsena) (Brunelli, 1926) with specimens from Lake Como (Chiappi, 1933). It is still present in Lake Bracciano, but has disappeared from Lakes Vico (P. G. Bianco, pers. Observ.) and Bolsena (Taddei *et al.*, 1999) (Fig. 1).

*Croatia, Montenegro, FYROM, Albania*: apparently present only in Lake Skadar (Vukovic & Ivanovic, 1971; D. Maric, pers. comm.), where both landlocked and migratory forms spawn, but in different substrates and seasons (Rakaj & Crivelli, 2000). The species appeared in fishing statistics for Lake Skadar until 1987. After construction of the above-mentioned dam, the twaite shad rapidly decreased and at present the lake maintains only a small population of probably the landlocked form (Maric & Kazic, 1990; M. Maric, pers. comm.). Another population is known to live in Lake Ohrid, FYROM (Tocko & Jovanovic, 1959), but we have no recent information about the status of the shad in this lake.

## 3. Variability of general morphology and taxonomic implications

The main morphological distinction between the migratory and landlocked forms (Tortonese, 1970) is the shape of the body and the head: in the migratory form, the body is deeper and the head is longer. The number of gill rakers is quite variable, but the migratory form usually has 35-45, whereas the landlocked form has 50-60. However, there are two exceptions:

- 1) in the migratory form landlocked in Lake Omodeo in Sardinia, the number of gill rakers has increased and the body has become like that of the true landlocked form;
- 2) in Lake Skadar, true landlocked populations have a small number of gill rakers like the migratory form.

For the twaite shad, the number of gill rakers has a taxonomic value. Thus, several subspecies are reported for the Mediterranean area, sometimes with an overlap of distribution (Quignard & Douchement, 1991):

- *Alosa fallax lacustris*, reported in lakes of northern Italy, central Italy (where it was introduced) and Sardinia (where populations of the migratory form became landlocked following the construction of weirs);
- *Alosa fallax nilotica*, reported in eastern drainages of the Adriatic Sea, lakes of northern Italy, and Lakes Scutari and Ohrid in the western Balkans;
- *Alosa fallax rhodanensis*, reported in lakes of central Italy and Sardinia.

The taxonomy of Quignard & Douchement is difficult to follow since it is based on very variable and adaptive characters such as the number of gill rakers and the size of the head and body. Moreover, it is difficult to accept the coexistence of more than one subspecies in the same basin. Finally, a third taxon, *A. algeriensis*, is also reported for the island of Sardinia (Kottelat, 1997).

Counts of gill rakers are quite variable and differ from lake to lake. For instance, in Lake Garda the mean number of gill rakers (standard deviation in parentheses) in 249 fishes was 60 (4) (Novello & Oppi, 1985; Oppi & Novello, 1986), while in Lake Skadar,

the landlocked populations (40 fishes, with a slender body and short head) had 31–35 gill rakers (mean 33.4) (Ivanovic, 1973). The number of gill rakers in the Lake Skadar fishes corresponds to that of the migratory form, which should be the result of trophic habits since the landlocked form shows the same benthic habits as the migratory form (Ivanovic, 1973). This is probably due to the shallowness of Lake Skadar (max. depth about 9 m), which does not permit development of the large planktonic communities that usually live in deep lakes (Karaman & Beeton, 1981). This indicates a good ability of the shad to modify its trophic habits and its ‘gill raker filter’ in a few generations according to the local ecological conditions and food availability.

#### 4. Remarks on the biology and feeding habits

The two eco-phenotypes ‘Cheppia’ and ‘Agone’ have a different biology and feeding habits. When landlocked, running populations of ‘Cheppia’ tend to assume all the characters of the landlocked ‘Agone’. In contrast, there are no reported cases of ‘Agone’ becoming migratory.

##### a. Landlocked populations

*Italy*: sexual maturity is reached at age 2+ in males and 2+ or 3+ in females, at a total length of 19–24 cm. Most frequent age classes of mature adults: II, III, IV. Longevity: 5 or 6 years. The spawning season extends from May to July, with some cases of reproduction in August. Sex ratio about 50 %, with local or seasonal fluctuations. Maximum activity in June with local maxima in May or July. Maximum total length 35–38 cm, maximum weight 400–500 g (Malfer, 1922; Berg & Grimaldi, 1966; Oppi & Novello, 1986; Negri, 1993; Confortini, 1998). The resident form is mainly a plankton feeder. In populations of northern Italian lakes, the diet is composed mostly of Cladocera and Copepoda (crustaceans), but there is a seasonal variation of these components. Copepoda is the major component of the diet from November/December to March/April, while Cladocera is the main component from April/May to October (Oppi & Novello, 1985; Negri, 1993; Confortini, 1998).

*Montenegro*: in Lake Skadar, spawning occurs in spring. According to Vukovic (1961) and Rakaj & Crivelli (2000), both migratory and landlocked populations of twaite shad live in Lake Skadar, but they are spatially and reproductively isolated. The migratory and landlocked forms have the same feeding habits, which consist of benthic components. However, unlike the situation in Italy, both forms show the same range of gill rakers. Nevertheless, for other parameters, they show the same differences as between ‘Agone’ and ‘Cheppia’ (Table 2). The adults of the landlocked form are mostly aged 2+ and are bottom feeders. Food items in small and medium-sized specimens are mostly crustaceans, with a high percentage of Amphipoda and Isopoda. Larger specimens may feed on small benthic fishes such as gobiids, blennids, *etc.* (Ivanovic, 1973).

Table 2. Monthly spawning activities observed in populations of landlocked and migratory twaite shad from several lakes and river basins of the study area. Abbreviations used: + lowest density, ++++ highest density; RU, running upstream; RD, running downstream.

| Landlocked form of <i>Alosa agone</i> 'Agone'  |               |                   |      |        |          |        |                               |
|--|---------------|-------------------|------|--------|----------|--------|-------------------------------|
| Lakes  | March         | April             | May  | June   | July     | August | Main References               |
| Garda  |               |                   | +    | ++++   | +++      | +      | Oppi & Novello 1986           |
| Maggiore                                       |               |                   | ++   | ++++   | ++       |        | Berg & Grimaldi, 1966         |
| Como   |               |                   | +    | ++++   | ++       |        | Negri, 1993                   |
| Skadar   |               | ++                | ++++ | ++     |          |        | Ivanovic, 1973                |
| Migratory form of <i>Alosa agone</i> 'Cheppia' |               |                   |      |        |          |        |                               |
| Rivers   | March         | April             | May  | June   | July     | August | Main References               |
| Po   | RU ++         | RU ++             | ++++ | ++ RD  | Run down |        | Gandolfi <i>et al.</i> , 1985 |
| Tiber  | RU ++         | RU+++             | ++++ | +++ RD | + RD     |        | D'ancona, 1927                |
| Tirso  | RU +          | RU ++             | ++++ | ++ RD  | RD       | RD     | Cottiglia, 1963a              |
| Skadar<br>(past)                               | RU++          | RU++              | ++++ | ++     | RD       |        | Vukovic, 1961                 |
| Rhône  | RU<br>(males) | RU++<br>(females) | ++++ | +++ RD | RD       | RD     | Rameye <i>et al.</i> , 1976   |

### b. Migratory form

*Italy*: sexual maturity is reached at age 3+ or 4+ in males and 4+ or 5+ in females, at a total length of 22-36 cm. Most frequent age classes of adults: IV, V, VI, VII. The sex ratio is similar for both sexes, but males reach the spawning grounds about 2–3 weeks before females and then leave before the females. Thus, the sex ratio seems to favour one or the other sex depending on the time of observation. Females are multispawners and each of them can reproduce up to 4–5 times in the same season. Maximum length about 60 cm. Maximum weight 1600-1800 gr. Maximum age 8–9 years (D'Ancona, 1927; Gandolfi *et al.*, 1985; Serventi *et al.*, 1991). The migratory form is a bottom feeder, the food items being molluscs and crustaceans. Larger specimens may feed on small benthic fishes such as gobiids and blennids. Table 2 shows a comparison of the spawning seasons of the two forms, with the months of major spawning activities.

### c. The case of 'Cheppia' of Lake Omodeo

Running populations of twaite shad in the Tirso River were landlocked after creation of the artificial Lake Omodeo in 1922. As a result, the biology and ecology of the populations in the lake changed, becoming very similar to those of 'Agone' of northern Italian

Table 3. Characters discriminating between *Alosa agone* from the River Tirso and from Lake Omodeo in Sardinia, where it was trapped in 1922.

| Character | Body    | Head    | Gill Rakers | Trophic habits | Total length |
|-----------|---------|---------|-------------|----------------|--------------|
| Tirso     | Deep    | Longer  | 46          | Benthonic      | Up to 45 cm  |
| Omodeo    | Slender | Shorter | 50          | Planktonic     | Up to 28 cm  |

lakes. Table 3 summarises the distinction after 80 years of isolation between the migratory Tirso River form (Cottiglia, 1963b) and the derived populations landlocked in Lake Omodeo (Cottiglia, 1963a). Compared with the original value in Table 1, the number of gill rakers has apparently not varied from 1966 to 2000.

#### d. Fluctuations of populations according to fishing catches

The landlocked 'Agone' is subjected to intensive fishing in all major lakes of Italy and in Lake Skadar. In Lake Maggiore (Fig. 2), the species disappeared from fishing statistics before 1979 (Giussani, 1989), but the populations increased from 1982 to 1995. There are no data for catches after 1995 because commercial fishing in this lake was suspended in 1996. In Lake Como, following a period of low density, the populations increased and from 1996 to 1999 the annual catches were 25–40 tons. Fishing of 'Agone' has been very important in Lake Garda (Fig. 4): since 1982, with a catch below 100 tons/year, the production has increased to 150–200 tons/year. In the Montenegrin part of Lake Skadar, the shad was one of the most important commercial species until 1963. However, production declined drastically after construction of a dam on the Bojana River (Fig. 4).

## Taxonomy

The number of gill rakers is usually adopted for taxonomic purposes in shads. The distinction between the allis and the twaite shad is quite evident because there is no overlap of gill raker counts (30–60 in *Alosa agone* versus 90–120 in *A. alosa*) and this distinc-

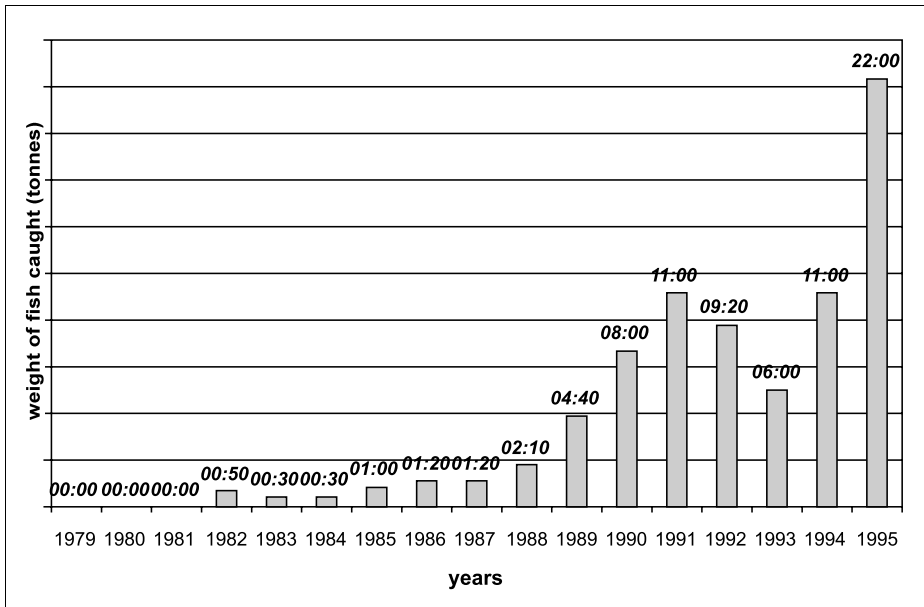


Fig. 2. Yearly catches of 'Agone' in Lake Maggiore (Grimaldi, 1997). Top numbers are tonnes.



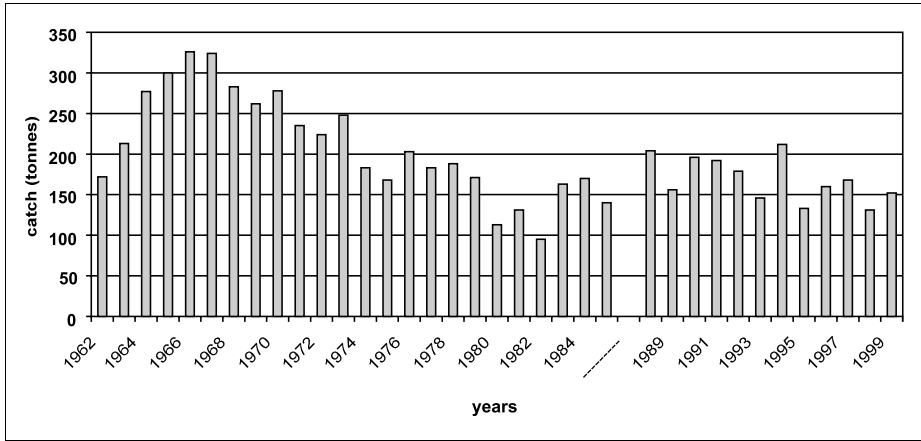


Fig. 3. Yearly catches of 'Agone' in Lake Garda (Oppi & Novello, 1986; Confortini, 1998 & pers. Comm.).

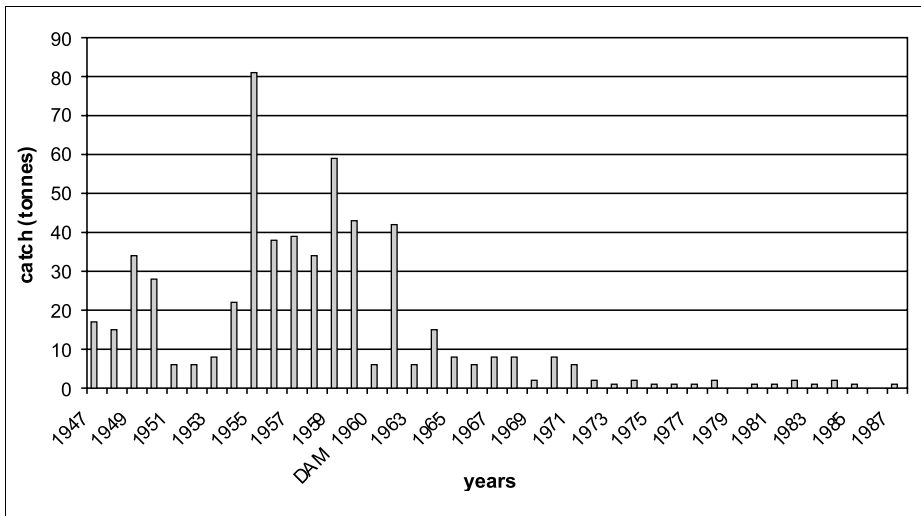


Fig. 4. Yearly catches of *Alosa* in Lake Skadar (Stein *et al.*, 1981; Maric & Kazic, 1990).

tion is also supported by genetic analyses (Boisenau *et al.*, 1992; Alexandrino, 1996; Alexandrino & Castro Linhares, 2000). However, the taxa belonging to the 'fallax' or 'agone' complex are difficult to separate. Several taxa have been described in the past, mostly according to body shape and number of gill rakers. For instance, Barbieri (1907) described three taxa for Lakes Maggiore, Como and Garda, respectively, mainly according to the different range of gill raker numbers. Later, Regan (1916) described another three taxa, again according to different numbers of gill rakers. Gill rakers, however, are also subject to ontogenetic variations and the number tends to increase with size, as observed in the Tirso River for the migratory form (Cottiglia, 1963b) and in Lake Como (Fig. 5).

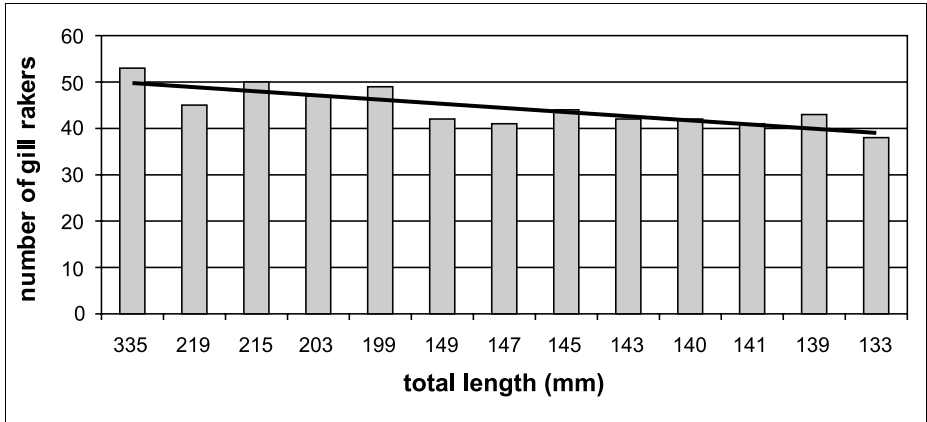


Fig. 5. Number of gill rakers in 'Agone' from Lake Como in fish of decreasing size and the regression line (Barbieri, 1907).

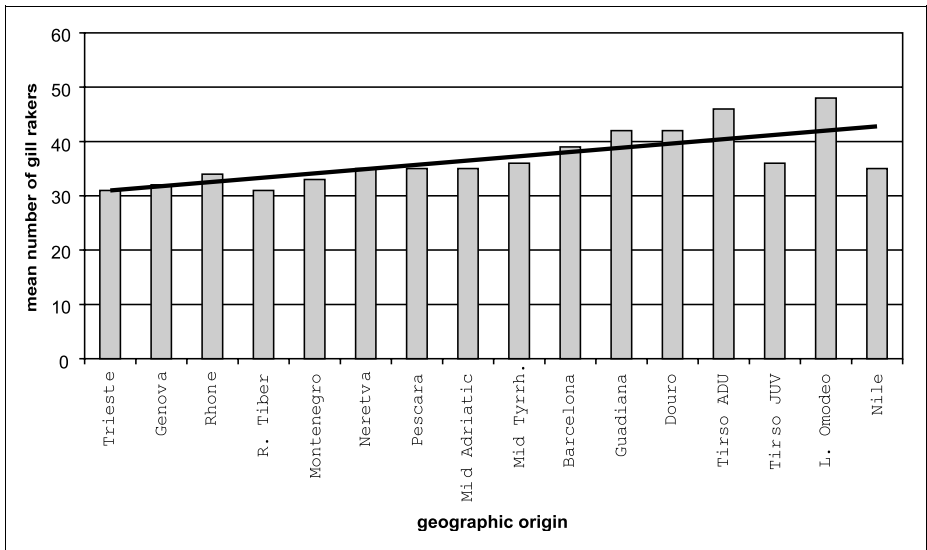


Fig. 6. Mean number of gill rakers in populations of migratory *Alosa agone* from north to south and the regression line (Barbieri, 1907; D'Ancona, 1927; Cottiglia b, 1963; Ferrero, 1951; Ivanovic, 1973; Rameye *et al.*, 1976; Costa Eiras, 1980; present study).

Fig. 6 illustrates the north-south geographical variation of the mean number of gill rakers in central Mediterranean populations. The mean increases from about 32 to about 48. According to this cline, only one taxon should be considered for the 'Cheppia' migratory form in the Mediterranean area.

The number of gill rakers is also quite variable in landlocked populations, varying from 32-34 in Lake Skadar to about 60 in Lake Garda, with intermediate values in

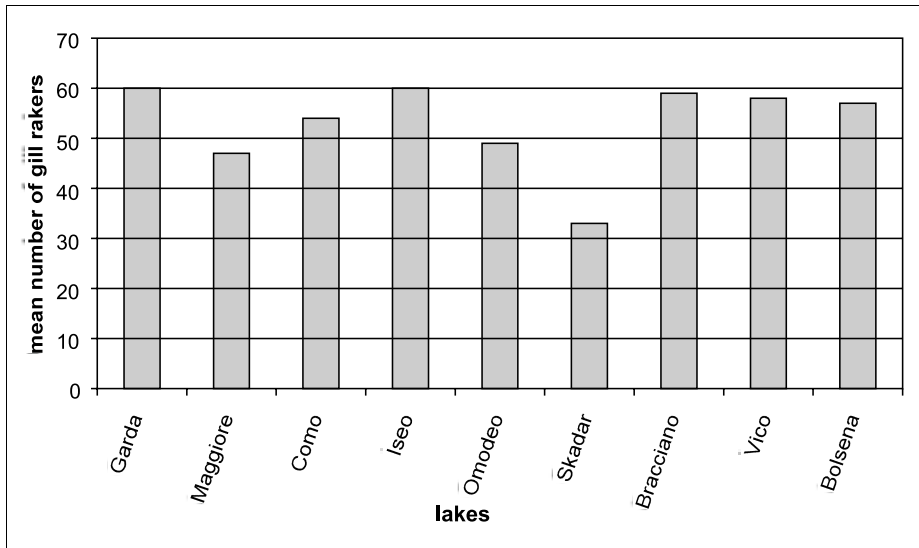


Fig. 7. Mean number of gill rakers in landlocked populations of *Alosa agone* from Italy and Montenegro (Barbieri, 1907; Cottiglia, 1963a; Ivanovic, 1973; Bianco, pers. Observ.).

populations of other lakes (Fig. 7). Table 4 summarises the main differences between the landlocked and migratory forms of twaite shad in Italy.

The case of landlocked shads in Lake Skadar and Lake Omodeo (Table 1 and Table 3) shows that the species is variable and able to modify its ecology, biology, feeding and morphology as a result of adaptation to freshwater or marine environments. Therefore, in the Mediterranean area we can recognise only one very variable taxon, which should be referred to *Alosa agone* (Scopoli, 1786) according to its first description for Lake Lugano in Switzerland (Kottelat, 1997). Table 5 reports the synonyms of this species. A question mark on *Alosa fallax* (Lacépède, 1803) indicates that this taxon, described for the western Atlantic part of Europe (Seine River in France) (Kottelat, 1997), is probably distinct from *A. agone*. According to Le Corre *et al.* (2000), there is an appreciable genetic divergence between *A. agone* from the Rhône basin (Mediterranean) and *A. fallax* from the Atlantic coasts.

Table 4. Characters discriminating between landlocked 'Agone' and migratory 'Cheppia' from Italian freshwaters and seas.

| Character | Body    | Head    | Gill Rakers (range) | Feeding habits | Total length (cm) | Spawning season | Longevity (years) | Age of first maturity |         |
|-----------|---------|---------|---------------------|----------------|-------------------|-----------------|-------------------|-----------------------|---------|
|           |         |         |                     |                |                   |                 |                   | Males                 | Females |
| Agone     | Slender | Shorter | 46–60               | Planktonic     | Up to 58–60       | April–June      | Up to 5–6         | 2+, 3+                | 3+, 4+  |
| Cheppia   | Deep    | Longer  | 28–36               | Benthonic      | Up to 28–30       | May–July        | Up to 8–9         | 3+, 4+                | 4+, 5+  |

Table 5. Synonyms of *Alosa agone* (Scopoli, 1786) for nominal taxa described for the Mediterranean drainage area (modified from Kottelat, 1997).

| <i>Alosa agone</i> (Scopoli, 1786)     |   |
|--|---|
| Synonym                                | Author (Type locality)                  |
| <i>Cyprinus agone</i>                  | Scopoli, 1786 (L. Lugano)               |
| *? <i>Clupea fallax</i> (Atlantic)     | La Cepède 1803 (R. Seine)               |
| *? <i>Clupea rufa</i> (Atlantic)       | La Cepède 1803 (R. Seine)               |
| <i>Clupea nilotica</i>                 | Geoffroy-Saint-Hilaire, 1808 (Nile)     |
| <i>Clupea finta</i>                    | Cuvier, 1829 (Type Loc. not designated) |
| <i>Clupea sardinella</i>               | Vallot, 1837 (Lakes North Italy)        |
| <i>Alosa finta lacustris</i>           | Fatio, 1890 (L. Lugano)                 |
| <i>Alosa lacustris ceresio-verbana</i> | Barbieri, 1907 (L. Maggiore & Lugano)   |
| <i>Alosa lacustris lariana</i>         | Barbieri, 1907 (L. Como)                |
| <i>Alosa lacustris benacensis</i>      | Barbieri, 1907 (L. Garda)               |
| <i>Alosa finta gracilis</i>            | Regan, 1916 (L. Garda)                  |
| <i>Alosa finta algeriensis</i>         | Regan, 1916 (Algeria & Morocco)         |
| <i>Alosa finta africana</i>            | Regan, 1916 (Algeria & Morocco)         |
| <i>Alosa finta rhodanensis</i>         | Roule, 1924 (R. Rhône)                  |

## Conservation

In Italy the landlocked form of twaite shad should be considered as vulnerable, according to IUCN (2000) categories, and the migratory form as endangered (Bianco, 1998). The situation in Croatia, Montenegro and Albania is similar (Mrakovcic *et al.*, 1995; Maric, 1995).

## Conclusions

The twaite shad is a highly polymorphic and adaptable species, able to modify its ecology, biology, feeding and morphology as result of adaptation to freshwater or marine environments. Only one taxon should be identified in the Mediterranean area, *Alosa agone* (Scopoli, 1786). The species undergoes local fluctuations depending on river flows, water quality, competition with other species and food availability. A pan Mediterranean-Atlantic genetic analysis of populations of nominal taxa or local forms of the genus *Alosa*, especially those inhabiting lakes in Italy and Montenegro, is needed in order to clarify the taxonomic position and the conservation status of Mediterranean and Atlantic populations.

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