Ecology

Identifying great crested newts

The great crested newt is the UK's largest newt, reaching a maximum adult overall length of up to about 170mm, although size varies between populations. Mature female length ranges from 90 - 170mm, typically reaching 110-130mm. Male newts may mature at a length of only 85mm (normally more), and grow to an adult maximum of about 150mm, though more typically 110-120mm. Adults are easily distinguished from the two other native newt species, the smooth and palmate newts, by size and colouring; these two smaller species reach a maximum of around 100mm. The skin of adult crested newts is granular in appearance. It has a black or dark brown background colour with darker spots, that in males extend onto the crest. It has very fine white spots on the lower flanks.

The male (above) has a jagged crest along the back that dips at the rear of the abdomen, and a smoother edged crest above and below the tail. The crest decreases in size outside the breeding season. There is a white, silver or grey stripe running from the tail tip along the central, fleshy section of the tail that fades as it approaches the abdomen. Females (below) lack a crest and white tail stripe, but have a yellow-orange stripe running along the bottom edge of the tail. Both sexes have a vivid orange or yellow belly with an irregular pattern of dark black spots or blotches. On land, the great crested newt appears virtually black, and in males the crest shrinks back against the body. Males of all newts have a relatively more swollen cloaca (vent).

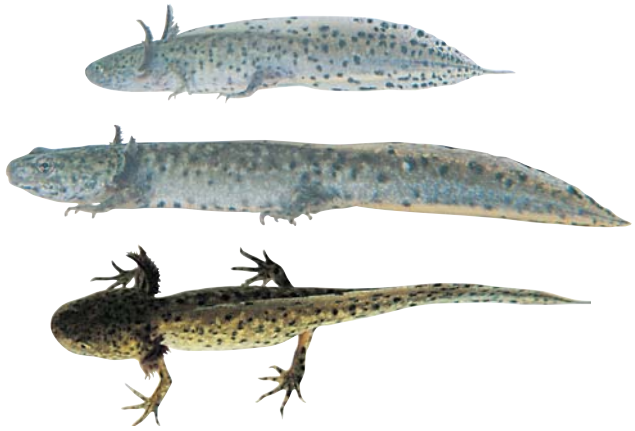
The adult male smooth newt (above) has a crest that is wavy rather than jagged, and it does not dip at the start of the top of the tail. It lacks obvious granules in the skin, and is generally lighter in overall coloration, often with roundish black spots. The belly may be superficially similar in appearance to that of the great crested newt, but the dark markings tend to be more rounded and usually fewer in number in adults.

Male palmate newts (above) have a protruding filament at the tail tip, with a low ridge along the back rather than a crest. Female smooth (below) and palmate newt (bottom) are very similar in colour and pattern, usually with a beige or brown background colour, with lighter undersides.

Great crested newt eggs have a jelly capsule around 4.5 - 6mm long, with a light yellowish centre, while smooth and palmate newts lay greyish-brown or dirty white coloured eggs, surrounded by a transparent jelly capsule that is about 3mm across. The larvae of great crested newts can be distinguished from the other species by the presence of a filament at the tail tip and black blotches over the body, tail and crest. They can be very hard to tell apart when they are under 20mm in length. The smooth and palmate newt larvae (which cannot be distinguished by eye) are light beige or brown, sometimes with fine black speckling. Great crested newt larvae are considerably larger, reaching a length of 50 - 90mm before metamorphosis (compared to 30 - 40mm for the smaller species).

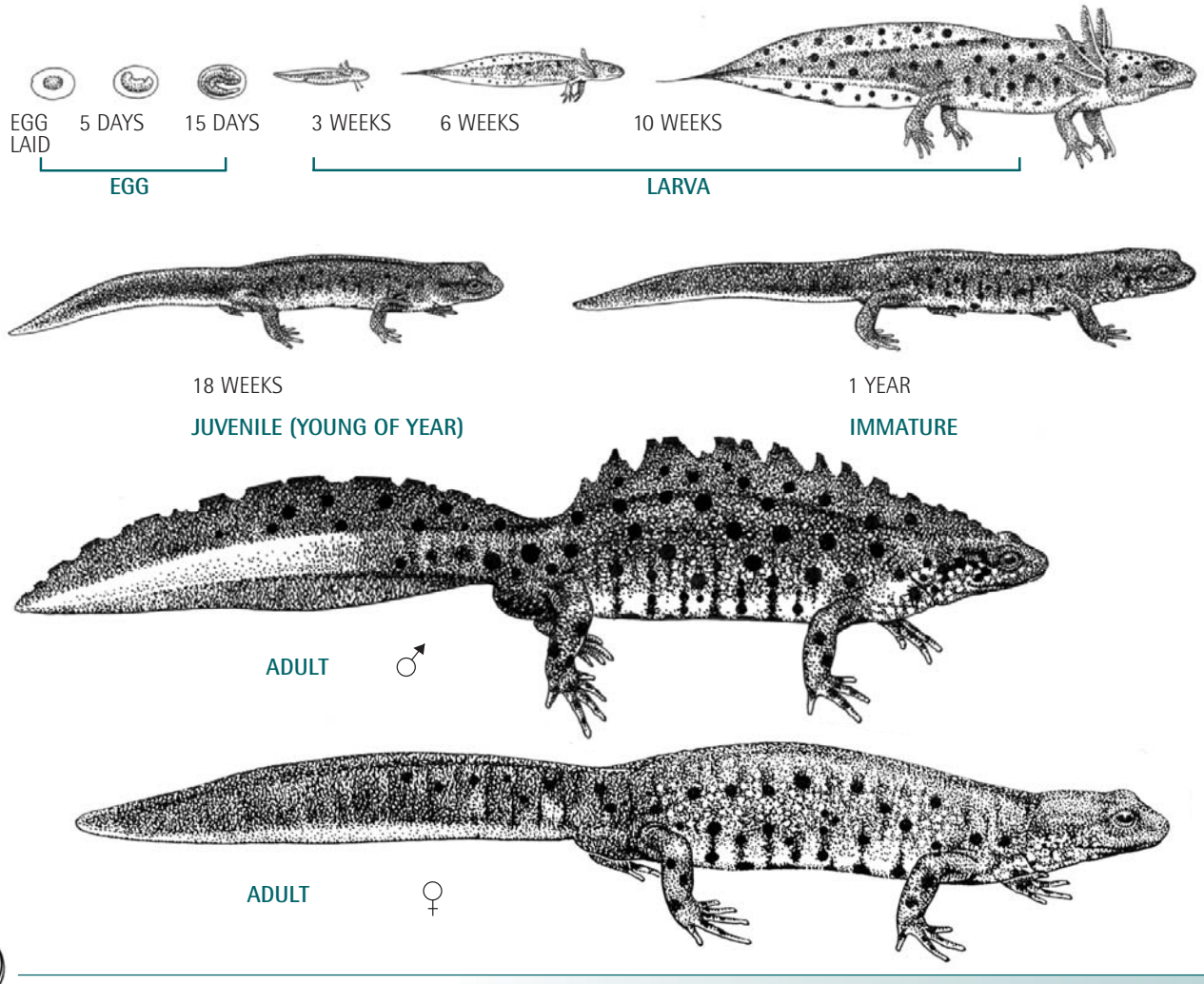
Newt larvae (tadpoles) - mid-term, approx life size

Metamorphosis of great crested newt (life size)



On leaving the water, great crested newt juveniles are similar in appearance to adults, apart from lacking the black spots/patterns that develop on the orange belly as they grow. The pattern becomes 'fixed' as the adults approach maximum size. Males start to develop the secondary sexual characteristics in their second or third season. This is marked by the appearance of the whitish tail stripe and the crest, and normally occurs when newts reach 90 - 120mm in total length. It is impossible to sex great crested newt juveniles externally, as the crest and tail stripe are absent.

Fig. 1 Typical growth and development of great crested newt shown at approximately life size



Exotic (introduced) European newt species can be encountered occasionally as the result of past release by universities, biological supply companies and hobbyists. Continental forms of crested newt are very difficult to tell apart from native British great crested newt without expert help and analysis. Crested newt species are known to hybridise and the spread of non-native species and their hybrids is a cause for concern. Other species such as alpine newt and marbled newt may also have life stages that are, to some extent, similar to those of great crested newts and have been mistaken for them in the past. If you are suspicious about the identity of newts, get them checked by an expert. The release of exotic newts in the wild is undesirable and unlawful and they have an effect on native species. Prompt removal of exotics can help prevent their spread.

Crested newts from outside Britain look very similar to our own. Those from more distant locations in central, southern and eastern Europe vary slightly in body/limb length ratios, in colour patterns and other subtle ways

Male alpine newt adult

Male alpine newt (belly lacks spots)

The breeding migration

As the newt breeding season immediately follows winter dormancy, adult great crested newts mature the eggs and sperm they will need for the next year in the previous summer and autumn. Adult newts may feed from the start of the breeding season in order to replenish reserves. Newts that have bred for at least one season may emerge from hibernation with their eggs and sperm ready for the new spring breeding season. Adult great crested newts normally begin moving from their over-wintering land sites between February and April. The timing of this movement is governed by a number of factors, particularly temperature and rainfall. The first of the newt emergence nights are normally wet or damp, with air temperatures above 4 - 5°C, following several days when the temperature has been just below this level. This makes it less likely that newts will be stimulated to emerge too early by a single unseasonably warm winter's day, only to then find themselves above ground or in the water when freezing conditions return. Movement over land occurs almost exclusively at night.

The migration of newt populations to breeding ponds is normally staggered, with some adults not reaching the pond until May. The earliest arrivals tend to be males. Migration dates are often later to the north and east of Britain, as they are for frogs and other amphibians. There is considerable variation between individuals in the amount of time spent in breeding ponds. Having entered in early spring, adult newts may spend anything from one day to seven months or more in a pond. At one well-monitored site in England, a third of the population occupied the pond for less than ten days. Therefore, shortly after the main movement into ponds, there may be a period of emigration when newts leave to forage or disperse on land. Newts may also repeatedly move in and out of the breeding pond, as well as between ponds, over the spring and summer.

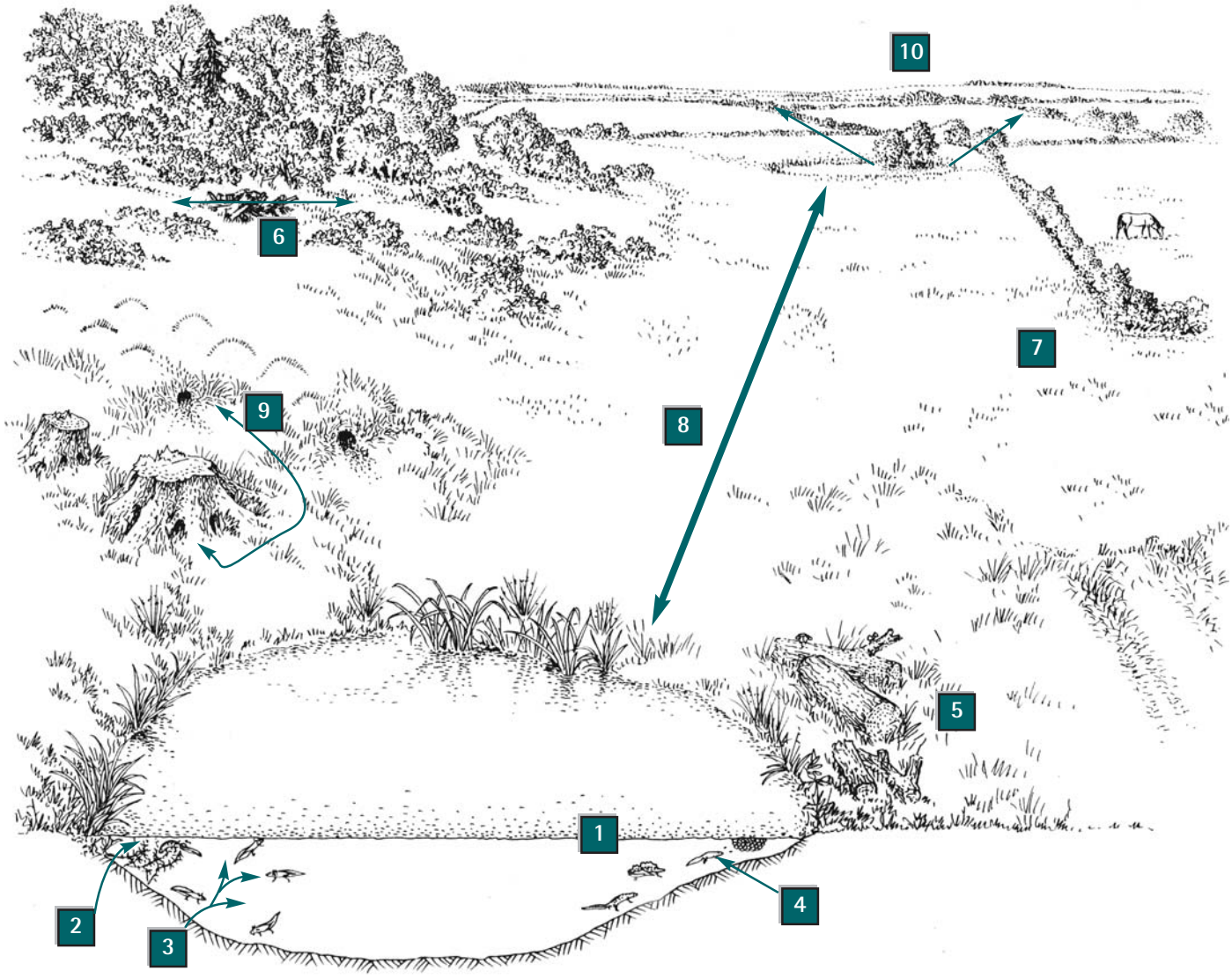
The main period when breeding adults generally leave the pond is between late May and July. This movement occurs gradually, with most newts having left by August. A proportion however may stay on until October and even, in some ponds, over winter amongst pond sediment and debris. Emigration from the pond usually coincides with periods of rainfall, and there is evidence that newts may leave a pond at or around the same point they entered it, indicating that they return to favoured parts of the terrestrial habitat that they somehow recognise. After leaving the pond, newts generally seek underground crevices or concealed above ground refuges.

Adult activity on land

On land, great crested newts generally engage in searching for food or dispersing and resting. In summer and autumn when conditions can be very dry for many weeks or in winter when conditions are too cold, they are not seen above ground.

Foraging above ground occurs mostly at night, and newts feed over a range of habitat types that support invertebrate prey. Newts may also forage for food underground in mammal

Fig. 2 Habitat use by great crested newts at a two-pond site



1 Display and courtship in the open pond margins
2 Egg laying on floating and submerged marginal vegetation
3 Larvae forage for invertebrates in all zones of ponds
4 Adults feed on other amphibians and invertebrates
5 Adults, immatures and juveniles under refuges during day
6 Foraging and over-wintering in undergrowth and litter layer
7 Foraging in rough grassland, pasture and hedgerow
8 Movement of adults between ponds
9 Refuge in mammal burrow and tree stump voids
10 Dispersal of some adults and immatures to distant sites

burrows during the day. They have two strategies: active searching for food and 'sit and wait'. 'Sit and wait' tends to be used at the edge of a refuge, burrow or crack and is more prevalent when the temperature and dampness suitable for foraging are borderline. Rough grassland, scrubland and woodland appear to be favoured foraging habitat. Newts are generally more active on warm, wet evenings or those following rain. They feed on a range of invertebrates, such as earthworms, insects, spiders and slugs. They seem to be rather unselective and their diet at a given place will probably reflect the availability of small, slow-moving invertebrates in the area. Great crested newts often take daily refuge under rocks, logs and discarded debris, where invertebrates collect, and so sheltering in these locations provides food as well as protection from predators and the extremes of weather. When in ponds, newts can be active during the day, especially when cold nights are punctuated by warm sunny days. In general, however, there seems to be more activity at night when newts move up from the centre of pond bases into the shallows.

In winter, when night temperatures fall below about 5°C, great crested newts enter a period of low activity. The point in the year at which this occurs will vary with annual variations in weather, but generally begins in late September to mid October and most animals are dormant by the end of November. An overwintering site for a great crested newt may, like day refuges, be an underground crevice or crack, such as a void in a tree stump or bank, or under refugia such as rock piles or dead wood. It may be just deep in loose soil at, or close to, their summer resting places. At many sites, great crested newts

overwinter in woodland, where the tree canopy, undergrowth and litter layer help buffer the ground from exposure and freezing. A proportion of adult and immature great crested newts are more likely to over-winter in or close to the pond edge at sites with dense pond edge vegetation and nearby features such as mammal burrows or old tree stumps.

Young male great crested newt

Smooth newt adult female (left), male (right) and juvenile showing comparatively pale colouration.

Adult activity in water

Great crested newts have an elaborate courtship. This is made all the more spectacular by the male secondary sexual characters, which are the high, jagged crest and light-coloured tail-stripe. Sexual characteristics reach their maximum size and intensity during the breeding season (normally April - May). The male often chooses a temporary display area, which tends to be a more open, less vegetated part of the pond bottom. This is normally near the shallow margins of a water-body, but can be at a depth of up to about one metre. Areas suitable to perform courtship display may be defended by males, especially in ponds where such places are in short supply, as they are important to breeding success. An individual male may use one or more display areas in a given night. Male newts sometimes mimic females and lure other males away from display areas, in order to take over favoured spots.

The male employs a range of display behaviours, including rocking, leaning, tail-whipping and fanning. These latter two behaviours waft sexual attractants (pheromones) towards the female. Courtship movements take place in a particular order but may vary with the receptiveness of the female. If the female exhibits an interest in the full display, the male then leads her away, quivering his tail. The female follows and touches the male's tail with her nose, signalling readiness for his deposition of a small white mass of sperm and jelly (spermatophore) on the pond bottom. The pair then move so that the female is in position to collect the spermatophore in her vent, after which fertilisation of her eggs takes place internally.

Great crested newts in courtship

Adult great crested newts also feed in their breeding ponds, which can offer a rich and varied supply of prey. Most obvious in the early season are frog tadpoles, which in some cases can be eradicated completely by newt predation. The adults and

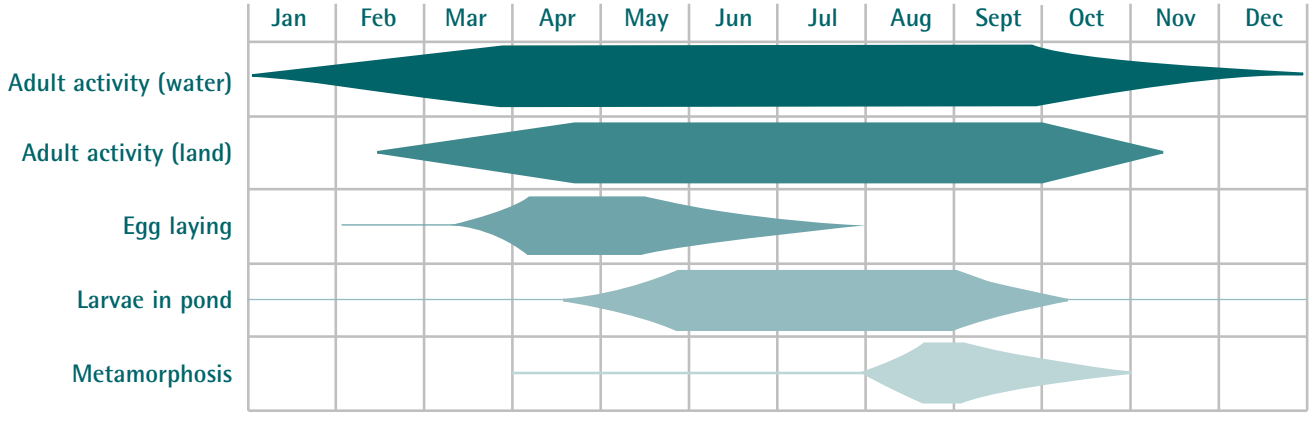


Fig 3 General timing and level of great crested newt activities over a calendar year

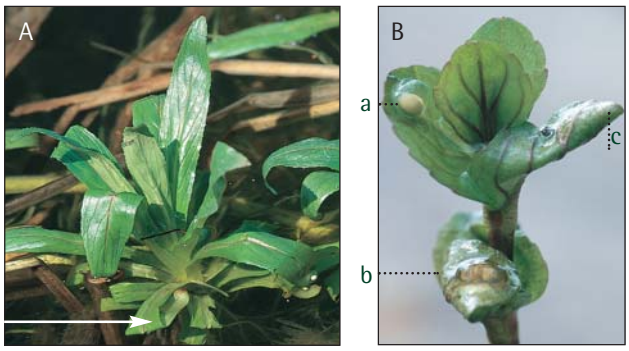
young of smooth and palmate newts and their tadpoles, and even a few toad tadpoles can also be taken. A range of invertebrates such as water lice *Asellus* spp., water shrimps, small snails, lesser water boatmen *Corixa* spp. and fly larvae (especially phantom midge *Chaoborus* spp). may be eaten. Zooplankton such as water fleas *Daphnia* spp., are a very important part of the diet because of the large biomass that builds up and becomes available as food for newts of all sizes.

Egg-laying

Female, noticeably plump with eggs at the start of her breeding season. Note the orange-brown colouration when seen at night by torch light

A breeding female will lay about 250 eggs per season, each egg individually deposited, typically on the submerged leaf of a marginal plant, under water and often close to the surface. The hind legs and feet are used to wrap the leaf around the egg, which is surrounded by an adhesive substance ensuring that the leaf encloses and protects it. A wide range of plants with thin and easily folded leaves are used for egg-laying (see *Planting new ponds* section page 28). Great crested newts may preferentially lay eggs on grasses (e.g. sweet or flote grasses *Glyceria* spp.), small wide-leaved plants (e.g. water mint *Mentha aquatica*), or narrow-leaved plants (e.g. water forget-me-not *Myosotis scorpioides*). Eggs are sometimes laid in folded dead or decomposing leaves, from the previous year's growth such as those of *Typha* sp. As well as aquatic plant species, terrestrial plants whose leaves dip into the water (or are submerged in

Female newt folding an egg into a water plant leaf



A Typical leaf folding in submerged leaf of great hairy willow herb

B Great crested newt eggs deposited on water mint a) freshly laid on surface, b) developing c) hidden in folded leaf

heavy rain) may occasionally be used; terrestrial grasses, bramble *Rubus fruticosus* and nettles *Urtica dioica* are examples. Sometimes eggs are left on the surface of leaves, on stalks, algae, old logs, roots and stones and debris such as plastic bags.

At the start of the breeding season females may lay just a few eggs per night, but as air and then water temperatures rise, by April they may lay ten or so eggs each day, with consecutively laid eggs often deposited on the same plant. On grasses and narrow leaved plants, several eggs can be laid on the same blade, leading to a repeatedly folded, concertina-like appearance. The main egg-laying season is mid-April to mid-June in most areas. However, eggs can sometimes be found in small numbers from February and into late July.

For more information on egg identification, refer to the *Survey Techniques* section on page 44.

Egg and larval development

Hatching rates of great crested newt eggs are dependent on temperature. Development varies according to the date of egg-laying and the type of pond. For example, it may take two weeks for an egg to hatch out in a warm, unshaded, shallow pond in June, while it could take three times as long if laid earlier in February or in a cool, heavily tree shaded pond. The timings given in the next paragraph are consequently typical values for eggs laid in mid-season in average pond conditions but they can be greatly slowed in cold weather.

Soon after being deposited, the spherical egg differentiates to form distinct head, torso and tail-bud regions. Due to a chromosome abnormality, 50% of great crested newt eggs die within a week or two at the early tail-bud stage. For the survivors, gills and balancers emerge during the second week, and striping starts to form over the cream background body colour. The eyes develop, body movement increases and hatching from the thin, clear egg-case surrounding occurs at around the 3rd-4th week. At first the newly hatched larva is a poor swimmer, and remains immobile, attached to the egg capsule or vegetation by the balancers. The forelimbs develop, followed by the hind limbs, and swimming ability increases

Great crested newt egg after a few days development in warm water

with short bursts of movement between resting. The larvae are a yellow colour with two grey stripes. At the same time, the gills increase in size and the mouth develops. By the sixth week from egg laying, the stripes have receded and black blotches become more visible on the tail fins. Larvae are tiny and hard to find until June. In July they are much bigger and easier to see, swimming in open water or resting on the pond base.

Larval great crested newts are highly predatory, feeding almost exclusively on aquatic invertebrates and small larval amphibians. Larval growth is greatly influenced by prey availability. There appears to be little selection, with prey being taken in relation to its availability in the pond. After the first few weeks, the larvae either swim and rest in mid-water, catch prey, or lie on the bottom of the pond in colder weather.

Great crested newt larva, just after hatching

Larvae can be seen in the water column in daylight although they are generally more active at night. Towards the end of the larval development period, when swimming ability decreases, great crested newt larvae become more benthic (living on the pond bottom), moving more into the margins of the pond. Known prey items include water fleas *Daphnia*, copepods, fly larvae, water lice *Asellus* spp., water shrimps, mayfly nymphs, young newt larvae (including great crested), and small common frog and common toad tadpoles.

Over the larval period, the overall body colouring becomes gradually darker, with black blotches spreading over the tail and body. The orange and black belly pattern starts to form between the forelimbs about mid way through the summer. Around this time, the gills and tail 'fins' gradually resorb into the body, and the previously smooth skin texture becomes more granular. The limbs and tail become more robust. After around 16 weeks, metamorphosis is completed when the gills and tail fins are totally resorbed, and the juvenile newt emerges from the pond onto land. Sizes of newly metamorphosed juvenile great crested newts vary greatly from around 45-90mm, more typically 60-75mm total length. Juvenile newts are known to emerge from ponds in a directional (i.e. non-random) manner. There is some evidence that they can recognise and follow the scent trails of other great crested newts. This might assist in finding high quality foraging habitat and refuges upon first emergence. For successful emergence, breeding ponds must normally retain water until the end of August.

Great crested newts normally reach sexual maturity aged between two and four years. During the intervening period, the immatures forage on land and sometimes in water, with some animals dispersing to the vicinity of new ponds. Growth and development again depends largely on prey availability, with maturity normally occurring sooner in more food-rich sites.

Males tend to mature sooner than females. Great crested newts can be relatively long-lived and have been recorded living up to fourteen years in the wild.

Population size and structure

Newts can fluctuate in number considerably from year to year for natural reasons. The drying out of ponds, a high number of predators, cannibalism and competition can all lead to major reductions in recruitment of young newts. These important factors may interact to affect different stages of the newt life cycle in different ways. For example, if fish colonise a temporary pond one spring, they may eradicate the whole larval cohort of that year but then suffer a local extinction themselves when the pond dries out in September. The result will be that there is no recruitment to the adult newt population from that year. If the pond refills as normal in winter and fish do not subsequently recolonise the pond, this incident may have little or no bearing on the overall viability of the population in the long term, due to the fact that newts can live for ten years or more.

Great crested newts suffer their heaviest predation during the egg and larval stages of their life cycle. Eggs are taken by water beetles, snails, newts, fish, waterfowl (indirectly with vegetation) and a few wading and diving birds. Eggs that become unwrapped from the leaf in which they were laid are likely to be more vulnerable. Fungi can also attack newt eggs. Larvae are prey to invertebrates such as water beetles and dragonfly larvae, as well as fish and even other great crested newts. During metamorphosis, the young newt's skin develops

glands containing toxins that make them unpalatable to most predators. Once individual newts reach the immature and adult life stages, their chance of survival on an annual basis increases dramatically. Even so, some birds (such as herons) as well as grass snakes have been known to take adults. It seems likely that some nocturnal mammals (rats, hedgehogs, foxes and badgers) may also prey on them occasionally.

Competition

Great crested newts may compete for food (on land and in ponds), space (particularly male display areas during the breeding season), and for egg-laying substrates in poorly vegetated ponds. The intensity of competition, and the effect that it has can vary enormously. Competition for food at the larval stage for example, may result in a smaller sized individual at metamorphosis, delayed emergence from the pond, or increased aggressive encounters between larvae. Even in established, nutrient rich ponds the supply of invertebrate food may be limiting. Other animal species may also compete with great crested newts for resources.

Metapopulations

Great crested newts often exist in metapopulations. A metapopulation is a group of associated populations. That is, a metapopulation is made up from newts which breed in, and live around, a cluster of ponds. There will be some interchange of newts between ponds, even though most adults consistently return to the same pond to breed. Metapopulations are much less vulnerable to habitat changes than populations based on single breeding ponds. For example, the early drying up of one pond in a cluster of, say four ponds, will not threaten the breeding success of all animals in the locality. As great crested newts can be relatively long-lived, populations can survive several years without successful breeding. Ponds will vary in their suitability for egg survival and larval development. Productive or 'source' ponds produce lots of young newts while unproductive or 'sink' ponds may not contribute to recruitment. Sometimes, ponds where surveys have shown lots of newts to be present are not productive, while those that are less obviously occupied by adults in the spring can produce many young.

Movement on land and colonisation of new ponds

Newts disperse over land to forage for food, and move between ponds. The distances moved during dispersal vary widely according to habitat quality and availability. At most sites, the majority of adults probably stay within around 250m of the breeding pond, so the density of individuals gradually decreases away from the pond. However, newts may well travel further if there are areas of high quality foraging and refuge habitat extending beyond this range. Disused railway lines and woodland patches in an intensive arable landscape are examples of such habitat. The rate of movement has been little studied, but some newts have been found to move 120m in one night. Like many amphibians, small numbers of individuals disperse as colonisers to distances of 1000 m or more.

Adult male great crested newt on land

Great crested newts are able to colonise a newly created or restored pond if, firstly it provides a suitable breeding habitat, secondly it is sufficiently close to the existing population, and thirdly, if the intervening habitat is conducive to dispersal and there are no significant barriers to movement. Newts may encounter ponds during their normal terrestrial activities, or may seek out new ponds, possibly using smell. In some cases, colonisation can be rapid, whilst in others it may take several years. Successful colonisation can be achieved by a small number of newts, with juveniles being the main dispersers. If breeding is successful the population may increase rapidly.

The distances over which newts have been known to colonise new ponds varies, but in general, nearer ponds are colonised more readily and quickly. Newts have been known to colonise newly dug ponds 300m away from existing ponds in the first year. The colonisation by newts of new ponds over 1000m distant from occupied ponds may take several years.

Habitat requirements

Great crested newts need both aquatic and terrestrial habitat. They prefer small to medium sized breeding ponds, around 50-250m^2, with smaller ponds being used more successfully where they occur in clusters. Very small ponds (e.g. garden ponds, small bog ponds) and larger lakes are usually not used. Breeding ponds should support aquatic vegetation for egg-laying. It appears that great crested newts prefer extensively vegetated ponds with a submerged plant cover of about two thirds of the pond and emergent/floating vegetation cover of one quarter to one half of a pond; in other words a well established, mid-succession pond. Ideally there should be open, less vegetated areas within the pond to allow adult males to display in clear view of females. Ponds that lack shade on the southern margin seem to be preferred.

Although great crested newts have been found in both acid and alkaline ponds (pH 4.4-9.5), they tend to be found more frequently in close to neutral or slightly alkaline water. They do not necessarily require permanent ponds. Temporary ponds which dry out every so often, can support very good populations, partly because periodic drying out reduces the

abundance of some of the most efficient newt predators such as dragonfly larvae and fish. Ponds also need to support a healthy (mainly invertebrate) fauna to provide food for developing larvae. Adult newts also feed in the water, so the presence of other amphibian spawn and larvae and invertebrates is beneficial. Great crested newts have been found to do particularly well where there are several suitable breeding sites in close proximity.

The primary requirements for great crested newt terrestrial habitats are that they should provide (1) permanent areas of refuge habitat for shelter in the more extreme weather conditions (i.e. drought in summer and freezing in winter), (2) daytime refuges, (3) foraging opportunities, and (4) dispersal opportunities. Permanent refuge habitat can be accommodated by ground cover of various kinds. Rough (especially tussocky) grassland, scrub and woodland may be used by newts as a shady refuge from hot, dry conditions. Broad-leaved woodland appears to be able to support higher densities of newts than coniferous woodland. With their permeable skins, newts are vulnerable to desiccation and need to be in contact with some form of moisture during the active season. For hibernation, newts seek out a location that affords them protection from winter conditions. Such places include underground crevices, tree root systems, mammal burrows, rubble piles or old walls. During the active season, immature newts and some of the breeding population may spend the daytime resting in thick ground cover, under shelters such as fallen trees trunks or in mammal burrows.

Foraging appears to take place in a range of habitats, but those where invertebrate prey are abundant, such as grassland and woodland, are particularly good. Movement between hibernation sites and breeding ponds, and also between neighbouring sites, can help to maintain populations (see below), and to allow this to happen there should be areas of suitable land habitat between breeding areas. Again, sufficient ground cover such as that provided by rough grassland is preferable, but great crested newts are able to cross stretches of bare open ground. Barriers to regulate migration and dispersal include roads with high traffic volume, built-up areas, large or fast-flowing rivers, and large expanses of intensively farmed land.

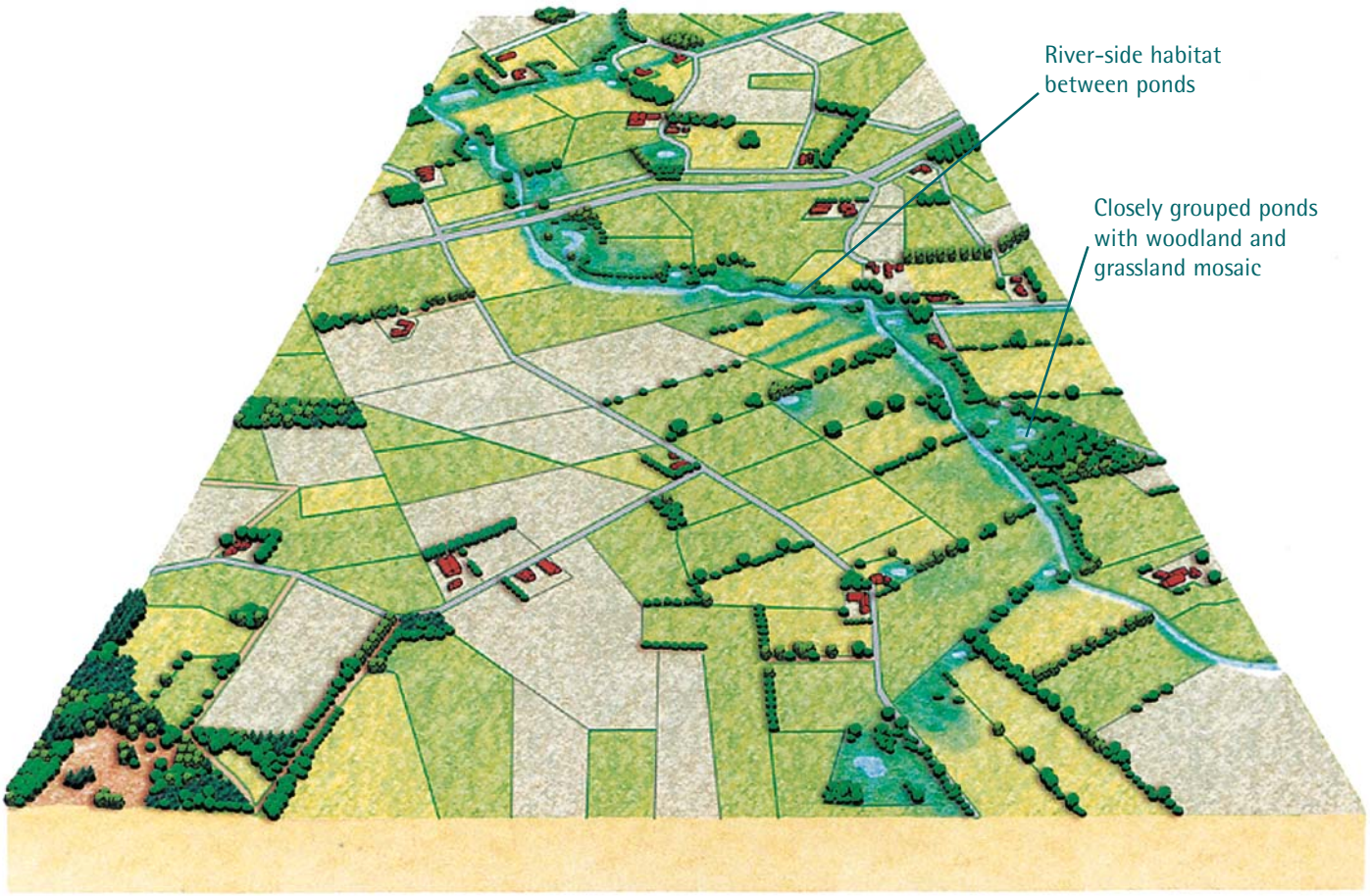
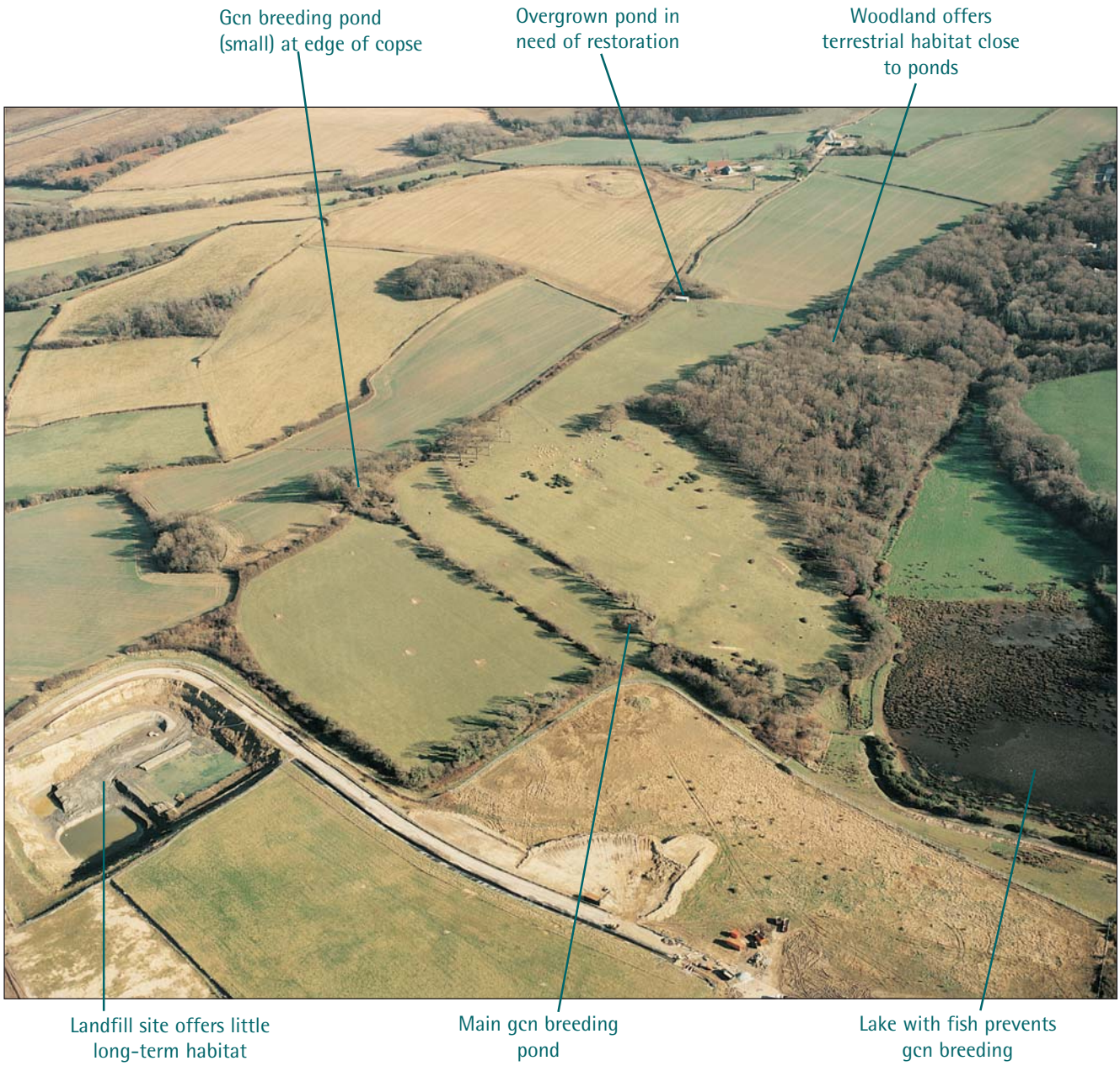


Fig. 4. Great crested newts in the landscape. Ponds act as stepping stones for newt dispersal in the landscape. In this example, features such as hedgerows and woodlands, ditches and river banks act as habitat corridors between the ponds and prevent the newt metapopulations from being isolated. Adapted from Alterra/The Pond Life Eco Project.



Typical great crested newt (gcn) distribution showing existing and potential breeding ponds in a metapopulation within mixed arable and livestock farming. The influence of urban land use (landfill site) encroaches from one side

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