- **Growth rates**. Within ranges of tolerance for the species, growth is faster at warmer temperatures.
- **General well-being**. Fish kept out of their preferred temperature range for prolonged periods are more susceptible to disease.
- **Willingness of fish to spawn**. Generally, willingness to spawn decreases as temperatures move away from preferred ranges, especially if temperatures are too low, though a small overnight drop can actually help in a few cases. A sustained increase of around two degrees in water temperature may encourage spawning in some species, while for others, notably some corydoras and goldfish, a drop of 3° to 4°C (5.4° to 7.2°F) overnight can induce spawning. Significantly, for most egg-scatterers, a change to fresh water and a good spawning environment is so conducive to spawning that a drop or increase of a degree or two in temperature makes little if any difference, and the change may even be helpful.
- **Hatching time for eggs**. Within their range of tolerance, eggs hatch faster at higher temperatures than lower.
- **Hatch rate of eggs** (the percentage that hatches). All fishes' eggs are sensitive to temperature to some degree, but characins' eggs in particular are inclined to be detrimentally affected by high temperatures. This means that the optimum temperature range for hatching most characins' eggs is somewhat lower than for most other tropical species. More specific information is given later.
- **Higher temperatures increase the proliferation of fungus, bacteria and protozoa** which can be very detrimental to eggs and larvae.
- The **effect of some toxins**, such as ammonia, is influenced by temperature (and other factors.)
- **Dissolved oxygen levels** are affected by temperature – the warmer the water, the lower the levels of oxygen that will remain in solution and available to fish.
- **Fish are more easily stressed as temperatures approach the higher or lower limits of their tolerance. Handling fish in these circumstances can be difficult**. In particular it is advisable to delay harvesting if temperatures are unfavourable. At high temperatures reduced oxygen levels can worsen the problem.
- **Chemical and biochemical processes are accelerated by warmth**. This includes the metabolism of fish, which is said to double for every 10°C rise in temperature within their normal living range. Oxygen is essential to many biochemical processes, and its availability in water declines as temperature rises. For this reason, deterioration in water quality tends to occur more easily and very much faster at higher temperatures than lower.

Later in the book, if actual temperatures are not given, the following categories of temperature are used:

Cold	–	below 22°C (72°F)
Cool	–	22° – 24°C (72° – 75°F)
Mid-range	–	25° – 26°C (77° – 79°F)
Warm	–	27° – 29°C (81° – 84°F)
Very warm	–	30°C (86°F) and above

Because the acceptable temperature range for grow-out is generally wider than for breeding, unless otherwise stated, when temperatures are suggested for individual species, unless otherwise specified these are given as an acceptable or preferred **breeding** range. It is in any case generally impossible and unnecessary to provide optimum temperatures for each stage of production for each species when working with multiple species in one facility.

See following page for **Temperature Conversion Table**.

Temperatures can also be converted arithmetically. To convert Fahrenheit to Centigrade, subtract 32, multiply by 5, and divide by 9. To convert Centigrade to Fahrenheit, multiply by 9, divide by 5, and add 32. For practical purposes, at sea level freshwater freezes at 0°C (32°F) and boils at 100°C (212°F).

to disinfect the filter. (There should be no significant ammonia build-up before the second day after introducing the fish if they are fed carefully.) Naturally it is essential to ensure as far as possible that the filter itself is free of any diseases already prevailing on site to prevent these from infecting the fish. For example, using a biofilter from a culture system containing consistently disease-free fish, or using filter medium drawn directly from an activating system. See 5.14 'Biological filtration' in PART 5.

(5) **Introduce new fish to the quarantine tank with great care**, ensuring that no potentially contaminated water is spilled, or droplets splashed or dropped – even onto the floor. (If water is spilled onto the floor, a little disinfectant such as chlorine or iodophor should be used to disinfect the area.) Newly arrived fish can be transferred to quarantine tanks by pouring them gently into a net resting on a small bucket partially filled with water, so that fish land in water and not onto a dry net. The net and bucket are carried to the quarantine tank, and the fish are transferred to the tank in the net while holding the bucket over, or as close to the tank as possible, to minimize dripping. The waste (packing) water in the bucket is kept isolated and disinfected later with a little chlorine or iodophor. After disposing of the water, the bucket and net used for the transfer are then disinfected in a chlorine/iodophor dip.

Note that stocking densities of fish in quarantine should be kept low, to optimize the fishes' well-being and to minimize the chances of water quality deteriorating.

(6) Immediately after introducing the fish, **cover the tank** as completely as practically possible to avoid cross-contamination by water droplets produced by aeration. Glass sheets or other non-porous, easily cleaned and disinfected material can be used as a cover. (Sheet plastic or Perspex, being light and unbreakable, are excellent.)

(7) Clearly **mark the tank 'QUARANTINE'** to avoid inadvertent cross-contamination by equipment or when feeding. Mark the tank with the **date of introduction of the fish**, to record the commencement of the quarantine period.

(8) **Feeding**. If available, live foods are usually best. They assist the fish in overcoming stress and rapidly regaining optimum health, and should produce a minimum of waste from uneaten food. Over-feeding with any food (which would require mechanical cleaning) must be avoided. Hands or any feeding equipment must not touch the water when feeding.

(9) **Any equipment used during quarantine must be disinfected**. Disinfectants such as chlorine or iodophor (such as Betadine) can be used at concentrations of around 200 ppm for about 15 minutes for chlorine, or following the manufacturer's directions in the case of iodophor. Liquid chlorine is generally easily available, and highly effective, but will destroy most kinds of netting after exposure. Chloramine T at the same or even higher concentrations is not as likely to do so, or does so less rapidly and is far more stable in water, but is less readily available for purchase and is more costly. Near-boiling water is another good, cheap, quick and clean option for disinfection, without any risk of contamination from 'carry-over' chemicals, but must be used with care to avoid burns to the user.

(10) **Observe fish closely for the entire quarantine period of preferably *at least 30 days*. In some circumstances a longer period is advisable. This would be the case for species of fish known to be potential carriers of particularly serious, slow-to-manifest or difficult-to-detect problems such as some sporozoa, GUD (goldfish ulcer disease), and lymphocystis or other viral diseases**.

If fish show any signs of ill health during quarantine, a sample specimen showing the symptoms is examined microscopically to see if the cause can be identified. Various possible actions are given in (11).

(11) During the quarantine period, depending on what occurs, the following action can be taken:

(a) If, after at least 30 days, fish remain healthy and no signs of disease appear, they can be released into the general production area, but preferably kept on their own for a further