5. GUIDELINES ON IDENTIFYING NON-PROCESSING LINKED EXTERNAL RISK FACTORS

Some external factors, not associated with a processing stage, can cause the fish to become infested. Once the timing and mode/s of infestation have been determined, and any processing risk factors have been identified, it is necessary to find out which external factors may be influencing infestation at the processing site. The following notes describe the external risk factors that are important in causing the infestation.

Rainy season

During the rainy season, the fish is more at risk of infestation.

- The prolonged high moisture content of the fish makes it attractive to adult blowflies and feeding larvae for longer. In addition, any eggs which are laid upon the fish at this time, are not likely to desiccate, and so more larvae will hatch to infest the fish.
- If the fish remain wet for too long they will spoil, and so become more attractive to the blowflies.
- Fish which is rained upon will spoil more rapidly, and so be more attractive to adult blowflies. In addition, it will have prolonged high moisture content, making it attractive to adult blowflies and feeding larvae for longer, and increasing the hatching rate of any eggs laid upon it.

Environmental conditions

The environmental conditions at a site on a particular day may increase the risk of infestation in the fish.

- If the air humidity is high, the fish will not dry quickly and so it will remain attractive to adult blowflies and feeding larvae for longer.
- Fish, which has been salted and dried, may regain moisture if the air humidity is higher than the water activity of the fish. If this happens, the salt content of the fish on a wet weight basis will decrease, and so blowfly larvae may be able to infest fish which previously was too salty.
- If the air humidity is very low, and / or the temperature of the air is high, the fish may suffer from case hardening. If this happens, the blowfly larvae will be able to feed upon the moist flesh in the centre of the fish and so the fish may be damaged during storage.
- Adult blowflies may be more active, and therefore more likely to lay their eggs upon the fish early in the morning and in the late afternoon, when the sun is less strong.

Hygiene

Blowflies are attracted to unhygienic processing sites.

- Blowfly larvae feeding upon the waste material on the ground may move onto and infest any fish, which are stacked on the ground.
- Waste material provides ideal conditions for the larvae to develop and pupate in.
- Both of the above points lead to large populations of blowflies at processing sites and therefore greater levels of infestation.

6. GUIDELINES ON SELECTING CONTROL MEASURES

Having determined the timing of the infestation, the mode by which it is occurring, and the processing and external risk factors, which may be influencing infestation, it is then possible to select control measures which are appropriate to the particular circumstances of the infestation.

Two checklists are provided to assist in identifying appropriate infestation control measures. Checklist 1 refers to processing risk factors, and Checklist 2 to external risk factors.

Both checklists contain control measures appropriate for each mode of infestation, influenced by each of the risk factors, and at each processing point. In some cases, more than one control measure may be suitable. In these cases, the most effective of the control measures is listed first. An appropriate control measure can then be selected, based upon its effectiveness, and the cost of applying it.

How To Use The Control Measure Checklists

1. Each checklist is divided into three columns; a question referring to the problem / risk factor, the control measure reference number (c.m.) given to each risk factor, and a description of the recommended control measure.
2. The checklists should be completed in a systematic way and in consultation with the processors. If a problem is recognised as significant, the relevant c.m. numbers should be noted for later discussion.
3. If more than one control measure is given for one c.m. number, the first one listed should be used whenever possible. When this measure cannot be used, the most suitable of the other suggestions can be used in its place.
4. In consultation with the processors, decide which control measures are appropriate to their individual circumstances. Bear in mind that if one of the recommended control measures will control the infestation caused by other risk factors, there may not be any need to apply the other measures. If in doubt, then apply all of the recommended control measures if this is feasible.

CHECKLIST 1. CONTROL MEASURES TO COUNTERACT PROCESSING RISK FACTORS

PROCESS STEPS & OBSERVATIONS	REF. No.	CONTROL MEASURE
1. Fish Purchase / Reception		
Is the quality of the processor's fish good?	c.m.1	a. If affordable / available, only fresh fish should be processed. If spoiled fish must be used, it should be inspected thoroughly for eggs and larvae. If present, the eggs and larvae should be physically removed by hand, by washing or by the infested part of the fish being cut away, before the fish is further processed.
Are the fish handled hygienically?	c.m.2	a. Fish must be handled hygienically at all times to prevent the spread of microorganisms. Processors should wash their hands, knives, and tables or other processing surfaces frequently. Care must be taken to not squeeze the fish so that the gut contents spill onto other fish.
Are the fish protected from adult blowflies?	c.m.3	a. Fish should be processed as soon as possible. If they must be held, insect proof containers should be used. b. If these are not affordable / available, the fish should be stacked on a clean processing table, or as a last resort, on clean sheeting on the ground, and covered with a fly proof net.
Are the fish protected from larvae?	c.m.3	a. Fish should be processed as soon as possible. If they must be held, insect proof containers should be used. b. If these are not affordable / available, the fish should be stacked on a clean processing table, or as a last resort, on clean sheeting on the ground. The ground should be cleared of larvae if fish are to be stacked there.
2. Pre – Salting Preparation		
Are the fish gutted?	c.m.4	a. Where possible, only fish which have been gutted immediately after capture should be used. If this is not possible, the fish should be gutted as soon as possible on arrival at the fish processing site. b. If it is not feasible to gut the fish, the fish should be protected from blowflies throughout the holding and processing stages. Suitable protection comprises fly proof holding boxes, lids on processing tanks and screens or netting erected over the drying areas. c. Spillage of gut contents onto fish flesh during handling (and gutting) must be avoided.
Are the fish beheaded or degilled?	c.m.5	a. It is preferable for all fish to be degilled before sun-drying, and added protection from blowflies is provided by beheading the fish. b. If it is not feasible to degill or behead the fish, applying large amounts of salt crystals to the gills and in the mouth of the fish may deter egg laying. c. If salt cannot be used, or if blowflies continue to be attracted to the fish, physical protection, (fly proof containers, lidded tanks and screens or nets) should be provided as long as the fish is attractive.

PROCESS STEPS & OBSERVATIONS	REF. No.	CONTROL MEASURE
		d. Where small numbers of fish are processed, any eggs laid in the gills or mouth may be manually removed. Applying salt crystals to any egg batches may prevent the eggs from hatching.
Are larger fish split?	c.m.6	a. It is preferable for all but very small species of fish to be split before salting or sun drying.
Are the fish processed by degilling and gutting, but not splitting?	c.m.7	a Fish, which are processed without splitting, but with the mouth and gills cut away, and the guts removed through the mouth cavity, must be physically protected from adult blowflies. Suitable protection comprises fly proof holding boxes, lids on processing tanks and screens or netting erected over the drying areas.
Are rough surfaces left when the fish are split?	c.m.8	a. The method of splitting should leave the split surfaces of the fish smooth. A butterfly type split will achieve this. If rough surfaces are left, they should be smoothed down with a clean hand to smooth out any crevices, which may otherwise be left.
Are the fish scored?	c.m.9	a. The scores should not penetrate the skin or the fish will fragment during transportation. However, the scores provide feeding crevices for egg laying and larval feeding. During sun drying, the scores should be forced apart, possibly with twigs, or similar, to open up the crevices and so remove any protection the crevices may provide to the eggs and larvae. These can be removed after the drying step. **Note:** Large fish should be scored to increase the surface area for salt penetration and water removal. b. If the scores cannot be held apart, frequently applying salt crystals into the crevices, so that a layer of salt is always present, may help to deter adults from laying their eggs in the crevices, and destroy any eggs and hatching larvae, which may already be present.
During preparation, are fish are held for long periods, without	c.m.3	a. Fish should be processed as soon as possible. If they must be held, protection from adult blowflies? insect proof containers should be used. b. If these are not affordable / available, the fish should be stacked on a clean processing table, or as a last resort, on clean sheeting on the ground, and covered with a fly proof net.
Are larvae present where fish are placed during preparation?	c.m.3	a. Fish should be processed as soon as possible. If they must be held, insect proof containers should be used. b. If these are not affordable / available, the fish should be stacked on a clean processing table, or as a last resort, on clean sheeting on the ground. The ground should be cleared of larvae if fish are to be stacked there.
3. Pre-Fermentation		
Are the fish pre-fermented?	c.m.10	a. The fermentation tanks must be covered with fly proof lids to exclude adult flies from the fish. Fish, which have been pre-fermented, must be physically protected from adult blowflies during salting and sun drying until they are no longer attractive to the flies. Fly proof lids should be fitted to salting tanks, and screens or nets should be erected over the drying areas. If fish are dry salted, they should always be salted in fly proof containers.

PROCESS STEPS & OBSERVATIONS	REF. No.	CONTROL MEASURE
Are the fish protected from adult blowflies during pre-fermentation?	c.m.11	a. During pre-fermentation, the fish must be protected from adult blowflies. This can best be achieved by covering the fermentation tank with a well fitting lid. b. In place of a lid, fly proof netting can be used, providing there is a gap of at least 2cm between the netting, and the top layer of fish in the tank. Care must be taken when removing the netting as eggs may have been laid on the netting, and these, or any hatching larvae, may be transferred onto the fish as it is removed from the tank.
Are the fish protected from adult blowflies during pre-fermentation?	c.m.11	a. During pre-fermentation, the fish must be protected from adult blowflies. This can best be achieved by covering the fermentation tank with a well fitting lid. b. In place of a lid, fly proof netting can be used, providing there is a gap of at least 2cm between the netting, and the top layer of fish in the tank. Care must be taken when removing the netting as eggs may have been laid on the netting, and these, or any hatching larvae, may be transferred onto the fish as it is removed from the tank.
Are fish which are already infested with larvae are being pre-fermented?	c.m.12	a. Fish should be inspected before they are pre-fermented or salted. Any fish found to be infested with larvae should either be discarded, washed, or the larvae removed by hand. b. If fish which are already infested with larvae must be processed, they should not be fermented or salted along with non-infested fish, as the larvae may move between the fish.
4. Salting		
Are the fish protected from adult blowflies during salting?	c.m.13	During the salting stage, the fish must be protected from adult blowflies. If the fish is salted in a tank, a lid should be fitted to the tank to stop the adult flies from reaching the fish. When fish are dry salted without using a tank, the fish must be carefully protected. This can be achieved by erecting a net or screen over the fish whilst it is stacked during salting. Alternatively, the fish could be wrapped in sheeting, but it is important that the sheeting is clean, free from holes, and is carefully wrapped around the fish ensuring that there are no gaps through which the flies can crawl. When brine is used, submerge fish with a weighted frame.
Are the fish protected from larvae during salting?	c.m.14	a. During the salting stage, the fish must be protected from feeding larvae which may try to crawl onto the fish from other food sources. Fish should not be placed in tanks, on tables, or on the ground if larvae are already present. The larvae must be removed and destroyed before the fish are placed in these areas. Fish should not be placed directly on the ground as larvae can move short distances to find new food. Instead, the fish should be placed in designated boxes or tanks for salting. Fish which is already infested with larvae should not be salted, as the larvae may move between the fish during the salting (see below). b. If designated boxes or tanks are not available / affordable, fish which are being dry-salted should be wrapped in clean sheeting, and the stacks should be raised off the ground.
Are fish which are already infested with larvae being salted?	c.m.12	a. Fish should be inspected before salting. Any fish found to be infested with larvae should either be discarded, or the larvae should be removed by hand. b. If fish which are already infested with larvae must be processed, they should not be salted with non-infested fish, as the larvae may move between adjacent fish.

PROCESS STEPS & OBSERVATIONS	REF. No.	CONTROL MEASURE
Are the fish salted for sufficient time to allow the salt to fully penetrate before being exposed to any infestation?	c.m.15	a. If salting is to be used as a blowfly control method, the salt must be equally distributed throughout the fish flesh. To achieve this, the fish must be salted to "equilibrium" (that is the time when no further salt will move into the fish from the brine), and salt penetration into the deeper muscles of the fish must be complete. This is likely to take several days. If it is not feasible to salt the fish for several days, salt cannot be used as a way of controlling larval feeding.
Is the salt content of the flesh likely to be less than 8% w.w.b?	c.m.16	a. If salting is to be used as a blowfly control method, the fish must be salted to at least 8% w.w.b. (that is 8g of salt in each 100g of undried fish). The salt must be equally distributed throughout the fish flesh. To achieve this, the fish must be salted to "equilibrium" (that is the time when no further salt will move into the fish from the brine), and salt penetration into the deeper muscles of the fish must be complete. This much salt may make the fish too salty for the consumer. If this is so, salt cannot be used to control larval feeding. b. If older larvae move to infest the fish, the salt content of the flesh must be greater than 8% w.w.b. This much salt may make the fish too salty for the consumer. If this is so, salt cannot be used to control larval feeding. c. If old brine is continually re-used, contaminants will build up which may render the salted fish more attractive to blowflies during drying. If the brine becomes too diluted, spoilage bacteria in numbers, affecting the quality of the fish and making it more attractive to blowflies. Ideally, fresh, fully saturated brine should be used for each cycle. The entrance to the salting vat should be protected by a waterproof lid.
5. Sun Drying		
Are fish being dried on the ground?	c.m.17	a. Whenever possible, fish should be dried on raised racks, or hung up to dry. This lets the air circulate around the fish, so that the moisture can be evaporated from all the surfaces of the fish. The fish will therefore dry more quickly and will not be attractive to blowflies for as long. Racks can be made from many locally available materials, such as wood, sticks or bamboo canes. The fish should be spread out to dry on trays, which can be rested across the top of the racks. b. If the fish must be dried upon the ground, they should not be spread out onto sand or earth. Instead, the fish should ideally be spread on clean concrete. If concrete is not available or affordable, clean matting should be used. This is because when the fish becomes very hot (as it often does when it is dried on the ground) the larvae will burrow into the sand or earth to escape from the heat. They will then re-surface when it is cooler, and begin to feed upon the fish again. If the fish is dried upon a hard surface, they cannot escape from the heat, and so they often die. The larvae can also use the sand or earth to pupate in. This helps to sustain the number of blowflies at the site. c. When fish are dried on the ground, any larvae, which are present on the ground, can move onto the fish and infest it. It is very important that the ground where the fish are dried is free of larvae, and any material in which they may be feeding, or on which eggs may be laid.

PROCESS STEPS & OBSERVATIONS	REF. No.	CONTROL MEASURE
Are drying trays are made from material in which the larvae can hide?	c.m.18	a. The trays should not be made from leaves, or other loose material, as larvae can hide amongst these where they are protected from the sun and from being noticed. It is better to make trays from netting or chicken wire stretched across frames, as there is nowhere for larvae to hide on these trays.
Is there is insufficient room on the drying rack to dry the fish without overlapping?	c.m.19	a. It is important that the fish do not overlap one another when they are spread out to dry. If they overlap, the part of the fish which is covered will not dry as quickly as the uncovered part. This part of the fish may then become infested during storage, as the moisture content may still be high enough to be attractive to blowflies. When fish overlap one another, it also enables larvae to move between the fish where they are overlapping, and so causes more fish to become infested. It is better to dry less fish at any one time, than to overload the drying rack. b. If it is not possible to dry less fish, the fish must be turned over very many times during the day, and care must be taken to ensure that all parts of the fish are exposed to the sun for some time during each day of drying.
Are the fish being protected from adult blowflies?	c.m.20	a. During drying, adult blowflies may lay their eggs upon the fish. The best way to stop this from happening is to erect screens or nets over the fish during drying. b If adult blowflies do lay their eggs upon the fish during drying, the eggs may be removed manually. It will be necessary, however, to check the fish at least twice a day. c. Alternatively, applying salt crystals to the eggs may stop the eggs from developing, and may kill any young larvae which are present. d. Turning the fish over many times during drying will keep the temperature of both sides of the fish close to the air temperature. If the temperature is high, larvae will be forced to leave the fish. Even if the larvae are not driven out of the fish by the temperature, turning the fish often will speed up the rate of drying, and so reduce the time that it is attractive to the adult blowflies and feeding larvae.
Are the fish being protected from feeding larvae?	c.m.21	a. Indirect infestation most often occurs when fish are dried on the ground, as larvae on the ground can easily crawl onto the fish and infest it. The best way to prevent indirect infestation is to dry the fish on raised racks. b. If the fish cannot be dried on raised racks, the next best way to stop indirect infestation during drying is to dry the fish on trays which can be supported on a raised platform c. When fish are dried on the ground, any larvae which are present on the ground can move onto the fish and infest it. It is very important that the ground where the fish are dried is free of larvae, and any material in which they may be feeding, or on which eggs may be laid. Fish should then be spread out to dry on clean mats. This can help to prevent the larvae from crawling onto the drying area, and so infesting the fish. d. Turning the fish over many times during drying may help to force any larvae to leave the fish, as the temperature of both sides of the fish will be kept close to the temperature of the air. This may be too high a temperature for the larvae to remain feeding. Even if the larvae are not driven out of the fish by the temperature, turning the fish often will speed up the rate of drying, and so reduce the time that it is attractive to the adult blowflies and feeding larvae.

PROCESS STEPS & OBSERVATIONS	REF. No.	CONTROL MEASURE
		e. Indirect infestation can occur when fish are dried on raised racks. This is usually because the fish is already infested with larvae when it is spread out on the racks to dry. The larvae will move between the fish on the drying rack, particularly if the fish are overlapping one another. To avoid indirect infestation, the racks should not be made from any material in which the larvae can hide, and they should be thoroughly cleaned after each batch of fish is removed, so that no larvae remain on the rack. If larvae are crawling up the legs of the rack to reach the fish on the drying trays, inverted cones made of stiff plastic, or old plastic drinking cups, can be fixed to the legs.

CHECKLIST 2. CONTROL MEASURES TO COUNTERACT EXTERNAL (NON-PROCESSING) RISK FACTORS.

PROCESS STEPS & OBSERVATIONS	REF. No.	CONTROL MEASURE
1. RAINY SEASON		
Are the fish is taking longer than normal to dry?	c.m.22	a. The extended drying time means that the fish remains attractive to adult blowflies and feeding larvae for longer. During the rainy season, fish should always be protected from blowflies. This can best be achieved by providing fly proof holding boxes, fitting lids to processing tanks, and by erecting screens or netting over the drying areas. Any areas where the fish are to be held must be free of larvae. b. If the fish are not protected, they must be checked twice a day for the presence of egg batches or feeding larvae. These should be removed manually. c. Applying salt crystals to any egg batches or hatching larvae may help to stop the eggs from developing, and may kill the young larvae. The success of this measure will largely depend upon the salt remaining in its crystalline form, and not dissolving in the excess moisture present on the fish.
Are extended drying times causing the fish to spoil?	c.m.23	a. Partially spoiled fish is much more attractive to adult blowflies than is fresh fish. If the fish is beginning to spoil, it should be protected from adult blowflies. This can best be achieved by providing fly proof holding boxes, fitting lids to processing tanks, and by erecting screens or netting over the drying areas. Spoiled fish is unlikely to be suitable for human consumption, and may need to be processed for animal feed or for fertiliser.
Are the fish are being rained upon?	c.m.24	a. Fish should be protected from the rain at all times. If fish are dried on raised racks, waterproof sheeting can be spread over the fish, or thrown over poles to form a tent during rainfall. This can be peeled back when the rain stops. If fish are dried under nets, sheeting can be laid on the fish. If fish is dried on trays, it may be possible to bring the fish under cover during rainfall

PROCESS STEPS & OBSERVATIONS	REF. No.	CONTROL MEASURE
2. ENVIRONMENTAL CONDITIONS		
Is the air humidity high?	c.m.25	a. If the relative humidity of the air is high, the fish will dry more slowly and so it will need to be protected from adult blowflies during sun-drying. Screens or nets should be erected over the drying fish. b. If this is not possible, egg batches and larval feeding packs can be removed by hand. c. Finally, applying salt crystals to egg batches and young larvae may help to destroy them.
Is salted fish being stored where the air humidity is high?	c.m.26	a. Salted fish should be stored in closed paper lined baskets to reduce moisture absorption from the humid atmosphere. If this happens, the salt content may fall below 8% w.w.b. and the fish will no longer be protected from feeding larvae.
Are the fish drying very quickly?	c.m.27	a. When drying conditions are very good, larger fish should be dried in the shade to limit the risk of case hardening. Shade can be provided by positioning drying racks under trees, or by hanging coloured sheeting above the drying area to stop the sun from shining directly onto the fish.
Are adult blowflies more active early in the morning and late in the afternoon?	c.m.28	a. If the blowflies lay their eggs in the early morning and /or late afternoon, the fish should be put out to dry during the period when the blowflies are least active. If the time of egg laying is mid-day, the fish should be covered with a net or screen, or with an insect proof sheet at this time. Studying the blowflies at the site will show what time of day they are most active and lay most of their eggs. (This is most often early in the morning and late in the afternoon).
3. HYGIENE		
Is there is a lot of fish waste and other debris at the processing site?	c.m.29	a. Discarding fish waste in or near areas where the fish are processed or stored will lead to indirect infestation of the fish. Fish waste provides an ideal place for the adults to lay their eggs and feeding larvae. The larvae hatching from the eggs will then move from the waste in search of more food. Fish nearby will become infested. In order to prevent this from happening, all fish waste and other organic waste must be carefully removed from the processing area and properly disposed off e.g. by burial. Some processors may be able to sell the waste for agricultural composting to make into fishmeal fertilizer or animal feed. If appropriate, issues of waste management and public health should be raised with local government departments or NGOs.
Is fish waste being discarded close to where the fish are stacked after drying?	c.m.29	a. Discarding fish waste in or near areas where the fish are processed or stored will lead to indirect infestation of the fish. All fish waste and other organic waste must be carefully removed from the processing area and properly disposed off e.g. by burial. Some processors may be able to sell the waste for agricultural composting to make into fishmeal fertilizer or animal feed. If appropriate, issues of waste management and public health should be raised with local government departments or NGOs.
Are waste material and other debris present beneath the drying racks processing tables?	c.m.29	a. This material provides ideal conditions for larvae to grow in. All fish waste and other organic waste must be carefully removed from the processing area and properly disposed off e.g. by burial. Some processors may be able to sell the waste for agricultural composting to make into fishmeal fertilizer or animal feed. If appropriate, issues of waste management and public health should be raised with local government departments or NGOs.

PROCESS STEPS & OBSERVATIONS	REF. No.	CONTROL MEASURE
Is there is a large population of blowflies at the processing site?	c.m.29	a. Poor hygiene and waste management lead to large populations of blowflies at processing sites. All fish waste and other organic waste must be carefully removed from the processing area and properly disposed of e.g. by burial. Some processors may be able to sell the waste for agricultural composting to make into fishmeal, fertilizer or animal feed. If appropriate, issues of waste management and public health should be raised with local government departments or NGOs.

Points To Consider When Selecting Control Measures

- Selection of control measures should be guided be an understanding of the processors existing coping strategies. Building upon the processors own ideas makes it easier for them to adapt the measures and include them into their current practices.
- Recommending too many control measures may cause disruption of the processors activities, resulting in poor uptake. Restricting control measures to those that yield most benefit and introducing them in a gradual way may be more effective.
- The control measures in the checklists may be added to or adapted to suit individual circumstances. Development workers should be flexible and use their judgement in selecting / modifying them.
- Some problems e.g. public sanitation and hygiene may be beyond the control of individual processors, as they involve wider participation of the community members and local government decision makers. Wherever possible, awareness of such issues should be raised at the appropriate level and community based interventions developed.
- Many small-scale processors are poor, averse to taking risks, and lack funds to invest in major improvements to their systems. Only those interventions that are affordable will be taken up by the processors. Where larger investments are necessary, they need to be linked to appropriate development support mechanisms e.g. micro-finance schemes.

REMEMBER

There is no such thing as a standard processing site or processor. Don't be afraid to use your judgement and adapt the control measures to the situation as you find it!

7. CASE STUDY EXERCISES

To familiarise themselves with the logic of the systems - based approach, trainees should complete the following desk based exercises before attempting to implement the approach in the field.

Kovviri and Malle's Fish Processing Site – Worked Example

Background

Kovviri Seethamma produces salted, sun-dried croaker (*Johnieops* sp.) during the monsoon season when the air humidity and rainfall are high. She buys her fish from fishermen on the beach. Because the fishermen do not carry ice, the fish she purchases are often semi-spoiled. She cannot afford the good quality fish, which is usually destined for shops and restaurants in the city. It may be several hours before Kovviri has bought sufficient fish to carry back to her processing site. The fish are kept in an open basket, exposed to the elements. When the fish arrives at the processing site, her sister, Malle, empties them on the ground and proceeds to gut them using a small sickle. Sometimes, several hours pass before Malle is able to commence processing the fish. Standards of hygiene are poor ar rhe site, fish waste is thrown onto a communal dump located next to the processing site and large numbers of blowflies are present. The nearby open-air public latrine also attracts many blowflies to the area. There are many blowfly larvae on the ground where the fish are kept and blowflies can often be seen laying eggs in the gills of some of the fish awaiting processing.

Malle processes her fish as follows. First she descales the fish. She then splits the fish along the belly before removing the guts. These she discards on the ground beside her processing table. The fish are then placed in a concrete vat containing brine that has been used many times before. Malle occasionally tops up the brine with sea salt and water, but seldom replaces it. During field trials it was noted that Malle's brine was on average 70% saturated with salt, but after heavy rains the saturation value could drop to as low as 50%. Malle places some large stones on the fish in an attempt to submerge them in the brine. She notices that several female blowflies are settling on her fish during salting and that large numbers of larvae are swimming in the brine. She covers the vat with palmyrus leaves and some plastic sheeting and leaves the fish to salt overnight. When she looks into the tank the following morning, she sees egg batches on some of the fish and notices that several of the fish are infested with small blowfly larvae. Malle is not worried about this as she has heard that salting the fish can protect it against blowfly infestation. She is certain that any larvae will die in the brine. After salting, Kovviri spreads her fish out to dry in the sun, on a bed of palmyrus leaves covered by fishing nets. A fishing net tent is erected over the fish to protect it from birds, but the mesh size is too large to prevent entry of blowflies.The fish takes 2 days to dry, and on the first day, she notices blowflies laying eggs on some of her fish. The fish are also attacked by larvae which crawl out of the bed of palmyrus leaves. At night she covers her fish with a waterproof sheet. Once her fish are dry she grades the fish and packs it in palmyrus leaf baskets before transporting it to market. On average, 20% of her fish is downgraded to poultry feed due to damage and discolouration.

What can Malle do to stop the fish from becoming infested?

Observations at Kovviri & Malle's Fish Processing Site

Gutting Fish on Ground

Fish Waste Infested with Larvae

Fish in Salting Tank

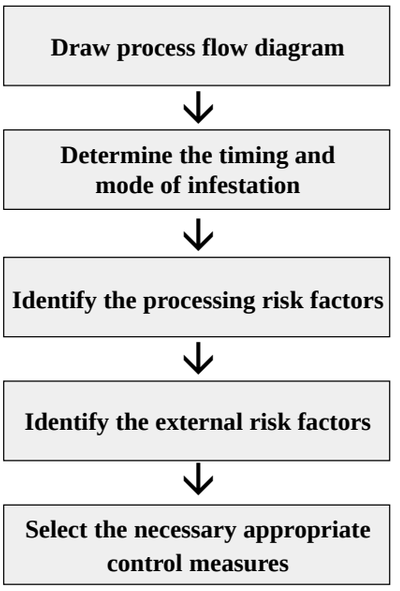
Infested Fish in Salting Tank

Fish Drying on Bed of Palmyrus Leaves

Downgraded Fish

USING THE SYSTEMATIC APPROACH TO CONTROL THE BLOWFLY INFESTATION IN KOVVIRI and MALLE'S FISH

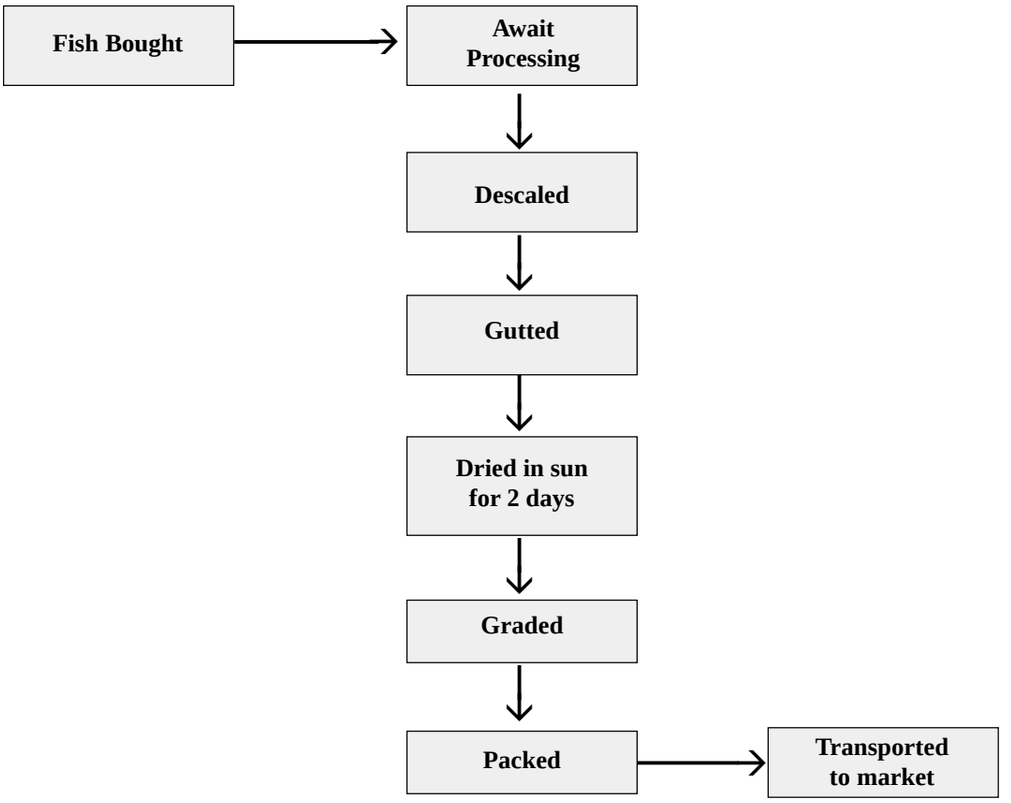
These are the steps which should be followed when using a systematic approach to control blowfly infestation:



Following each step;

1. The template flow diagram is changed to show the preparation stages followed by Kovviri and Malle.

FLOW DIAGRAM OF KOVVIRI AND MALLE'S PROCESS



2. Studying the fish processing with the help of Checklist I, it is possible to see where the fish are becoming infested and by what mode. The points and modes of infestation are:

   a) by direct infestation whilst the fish are held at the processing site awaiting processing

   b) by indirect infestation whilst the fish are held at the processing site awaiting processing

   c) by direct infestation during the salting stage as adult blowflies lay their eggs on the fish at the top of the salting tank

   d) by indirect infestation during salting as larvae already infesting some of the fish move onto adjacent fish in the tank

   e) by direct infestation during the first day of drying

   f) by indirect infestation during drying

3. As the fish are infested at the 'Awaiting Processing', 'Salting' and 'Drying' steps the processing risk factors up to and including these steps need to be considered. The questions in Checklist 1, up to and including those relating to the Drying step, are answered and the appropriate box after each question ticked. The answers to the following six questions have suggested control asures:

1.	Is the raw material of good quality?	Yes	☐	No	☑	→	c.m. 1
2.	Are the fish being handled hygienically?	Yes	☐	No	☑	→	c.m. 2
3.	Are the fish processed immediately upon arrival?	Yes	☐	No	☑	→	c.m. 3
4.	Are the fish protected from adult flies before processing?	Yes	☐	No	☑	→	c.m. 3
5.	Are the fish protected from larvae before processing ?	Yes	☐	No	☑	→	c.m. 3
6.	Are the fish beheaded or degilled?	Yes	☐	No	☑	→	c.m. 5
7.	Are fish protected from adult flies during salting?	Yes	☐	No	☑	→	c.m. 13
8.	Are the fish protected from larvae during salting?	Yes	☐	No	☑	→	c.m. 14
9.	Is the salt content of the fish likely to be at least 8% w.w.b.?	Yes	☐	No	☑	→	c.m. 16
10.	Are fish protected from adult flies during drying?	Yes	☐	No	☑	→	c.m. 20
11.	Are the fish protected from larvae during drying?	Yes	☐	No	☑	→	c.m. 21

4. Next, the questions relating to the non-processing risk factors in Checklist 2 are answered, and the appropriate box after each question ticked. The answers to the following three questions have suggested control measures:

1.	Is there a lot of fish waste and other debris at the processing site?	Yes	☐	No	☑	→ c.m. 29
2.	Are waste materials and other debris present beneath the drying racks?	Yes	☐	No	☑	→ c.m. 29
3.	Is there are a large population of blowflies at the drying site?	Yes	☐	No	☑	→ c.m. 29

5. Having identified when the fish are becoming infested and by what mode, and what processing and external risk factors may be influencing the infestation, the control measures recommended in Checklists 1 and 2 are looked up in the Table of Control Measures.

   The most appropriate control measures for Kovviri and Malle's operation are as follows:

c.m. 1	As unspoiled fish is unaffordable, raw material should be inspected for blowfly eggs and larvae and washed to remove infestation.
c.m. 2	Fish should be processed on clean plastic sheet and washed both before and after 'descaling / gutting' steps
c.m. 3	Fish should be processed as soon as possible. If they must be held, insect proof containers should be used,
c.m. 5	Fish should be degilled or beheaded
c.m. 13	A weighted frame should be used to completely submerge fish in brine. Entrance to salting tank should be guarded with closely fitting lid.
c.m. 14	Infested brine should be disposed of, the tank thoroughly cleaned and fresh saturated brine made up for each batch of fish.
c.m. 16	Fresh saturated brine should be made up for each batch of fish.
c.m. 20	Erect screens or fly proof nets over the fish during drying.
c.m. 21	Dry the fish on raised racks.
c.m. 29	Remove fish waste and other organic waste from the processing area and carefully dispose of by burial. Explore possibility of converting waste into fish meal etc. Raise waste disposal and public hygiene issues with relevant local government department.