Fact sheet
2024 | Switzerland | No. 1765

Duckweed – a useful crop

Feed for fish and other livestock

FiBL

Animal husbandry on land and in water accounts for a significant proportion of agriculture's ecological footprint. The poor ecological balance of animal husbandry is attributable in particular to the cultivation of feedstuffs. Globalised production and the import of animal feed also cause a wide range of problems worldwide. Locally produced feedstuffs, on the other hand, can increase the sustainability of animal feed in the long term. Duckweed is very suitable in this respect and can contribute in a meaningful way.

Contents

Animal feed and its ecological balance

In addition to the greenhouse gas emissions caused by the digestive systems of ruminants themselves, the poor ecological balance of livestock farming is attributable in particular to the cultivation and import of feedstuffs. The production of animal feed leads to the emission of harmful greenhouse gases, primarily through nitrogen leaching due to fertilisation practices and changes in land use.[1]

The deforestation and slash-and-burn clearance of rainforests in South America to create new cultivation areas is particularly problematic, as this destroys a globally important CO_2 reservoir. The protein-rich soya beans produced there are also fed to Swiss livestock.[2,3] The large-scale cultivation of animal feed is often accompanied by the increased use of pesticides and the over-fertilisation and acidification of the soil in cultivation areas. This contributes significantly to the large ecological footprint of animal feed and the animal-based foods produced with it, such as meat, fish, cheese, eggs and milk. The nitrogen imported with animal feed also causes a significant nitrate surplus in Switzerland, with negative consequences for groundwater and surface waters.

Animal-based feedstuffs

In addition to plant-based feedstuffs, animal-based feedstuffs are also used in livestock farming. One example is fishmeal, which, while fed to a much lesser extent than soya beans, has a comparatively poor environmental footprint. With a few exceptions, targeted fishing for fishmeal production is not considered sustainable, as around 90 % of the catch is of food or prime food quality.[4] Arable crop cultivation and fishing to produce feed for livestock compete globally with the resources available for human consumption. Feed production therefore jeopardises sensitive ecosystems and accelerates the ongoing loss of biodiversity.

Duckweed: opportunities and potential

Duckweeds are small floating plants that occur in temperate latitudes, subtropical and tropical regions. There are around forty different species, which prefer to grow in ponds, pools or very slow-flowing and nutrient-rich waters. They are able to absorb nutrients such as nitrogen (N) and phosphorus (P) very efficiently and achieve high growth rates under optimal conditions. Ideally, they can double their biomass within 24 to 36 hours.

The protein content of duckweed is comparable to that of soya beans: up to 45 % of dry matter[5], and because of its absorptive properties, duckweed has the potential to reduce the high nitrogen inputs from agriculture and pollution in water bodies.[6] Several possible uses for duckweed are discussed in more detail as of page 14.

The positive properties of duckweed have been researched since the mid-1970s. However, with a few exceptions of companies founded in the USA, the Netherlands, Germany or Israel, the research results have so far not lead to the establishment of any large industrial operations. This is because the production method and processing of duckweed must first be optimised for large-scale production. With the growing awareness of improved nutrient recycling and efforts to increase nutrient and especially nitrogen efficiency in agricultural production, interest in duckweed as a feedstuff is currently on the rise again.

In natural habitats, duckweed often occurs communitarised (here: *Spirodela polyrhiza*, *Lemna minor* and *Wolffia arrhiza*).

Duckweed as a nitrogen recycler

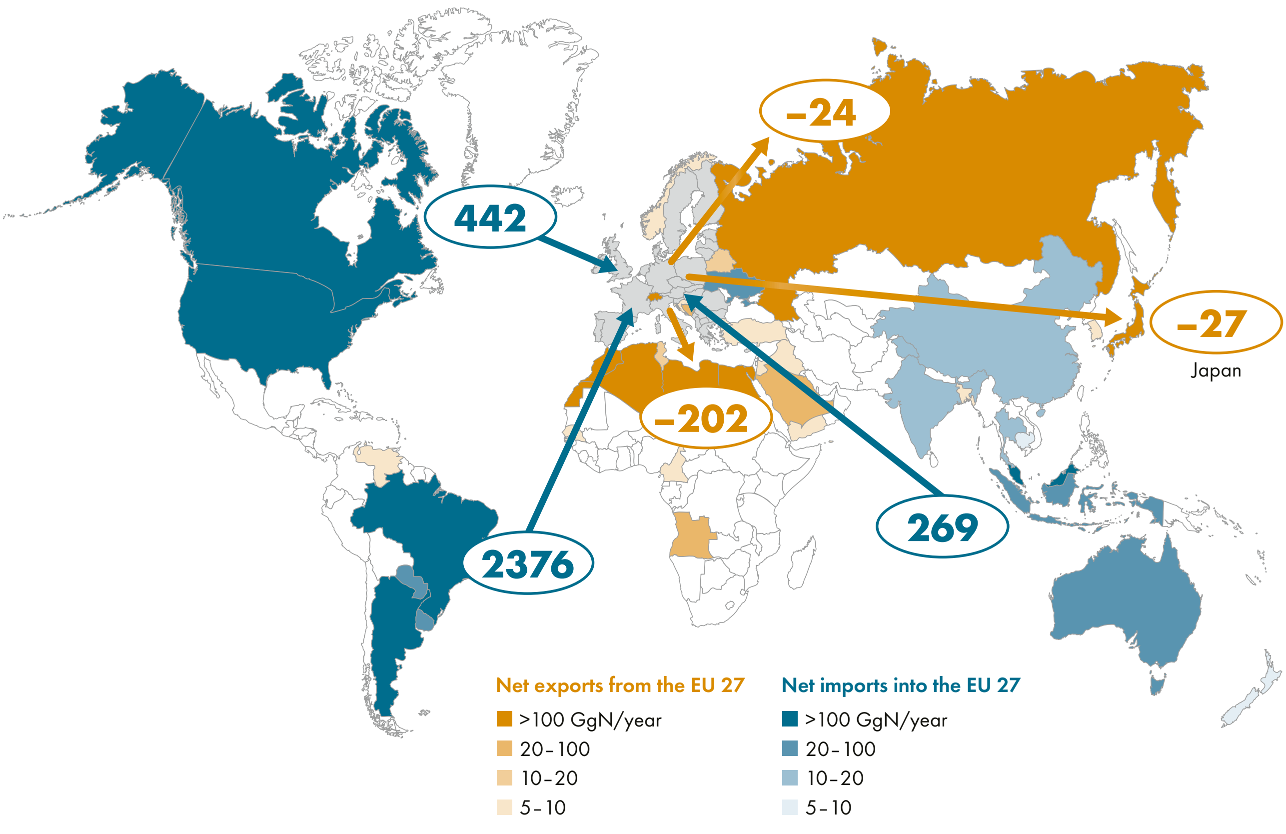
Compared to soya, duckweed produces many times more protein per area and vegetation period in nitrogen-rich waters and under optimal conditions. Even under restricted conditions, protein production is proven to be 9 times higher than that of soya.[7]

Duckweed prefers high ammonium concentrations (> 10 mg/l) in the water or substrate, high temperatures (> 20 °C) and plenty of light. The pH value should not be too high. Nevertheless, duckweed can cope well even with a pH of up to 8.5. Experiments have shown that duckweed even flourish in liquid pig manure.[7]

One of the problems caused by intensive agriculture and animal husbandry is a significant surplus of nitrogen in Europe due to imported fertilisers or animal feed (see Figure 1 below).[8] This nitrogen sooner or later ends up in nature and leads to nitrate surpluses causing eutrophication and deterioration of groundwater and the water quality of rivers and lakes.

Duckweed efficiently converts faeces and urine from animals or even humans into protein-rich biomass that could be used as feed for various animals. However, if animal manure or possibly even human excrement is used as a nutrient substrate, this inevitably leads to biosafety issues. In addition to the efficient uptake of nitrogen and phosphorus, duckweed also accumulates heavy metals that are harmful to health. Microbial contamination can also occur.

Figure 1: Nitrogen surpluses in the countries of the European Union as a result of intensive livestock farming



GgN = gigagram (1000 tonnes) of nitrogen

Nitrogen imports to Europe and Switzerland exceed exports many times over. Nitrogen flows must be seen in the context of European livestock production. Nitrogen imports result from imported fertiliser and animal feed, while European nitrogen exports relate to meat and livestock exports.[8]

Nutritional value of duckweed

As with other feedstuffs, the nutrients contained in duckweed are roughly categorised into macro- and micronutrients as well as trace substances.

Macronutrients include proteins, fat and carbohydrates, the amounts of which depend on the type of duckweed (Table 1 on page 6). Macronutrients provide the majority of the nutrients required for animal or human nutrition.

Amino acids are also of great functional importance. In animals and humans, these are released when food or feed protein is digested and metabolized. The so-called non-essential amino acids can be synthesized by the body itself. Essential amino acids, on the other hand, are absorbed through food. Duckweed contains nutritionally important amino acids in relevant concentrations (Table 2 on page 7).

Duckweed contains rather little fat, but has a low ratio of omega-6 to omega-3 fatty acids, which is favourable for human nutrition. In animal nutrition, the optimum fatty acid ratio depends on the animal species to be fed and its life stage. Depending on the production method and conditions, duckweed has a dry matter protein content of 18 to 45 %, with a range of 25 to 30 % being the most common. However, higher protein contents of 35 to 40 % can also be achieved without too much effort, as trials conducted by FiBL and the ZHAW have shown. The lipid content in the dry matter fraction is generally between 4 and 14 %.[9] However, one of the major disadvantages of duckweed as a feedstuff is its low dry matter content, which fluctuates on average between 5 and 8 %. The starch content can also vary greatly and ranges between 4 and 11 % of the dry matter.

Also of interest are a number of trace elements that are nutritionally valuable. There is scientific evidence that duckweed may contain vitamin B12,[10,11] which is a very important vitamin mainly ingested from animal-based foods. Duckweed also contains a number of antioxidants from the carotenoid group (lutein, violaxanthin, zeaxanthin and ß-carotene),[12,13] which have been proven to protect against radiation and cell damage.

Feed quality and usability

If duckweed is to be used as food or feed, the desired protein content, amino acid composition, fat content and fatty acid composition depend on the planned use. For example, in the rearing of freshwater fish, cold-water species such as salmonids (trout, salmon, grayling) tend to require omega-3 fatty acids, while warm-water species, on the other hand, require omega-6 fatty acids.[14]

The amino acid composition of duckweed proteins strengthens its suitability as animal feed and is comparable with other plant proteins such as those from soya or lupins. The essential amino acids lysine and methionine in particular are contained in comparatively high concentrations. However, the amino acid composition and protein content can vary considerably depending on the species of duckweed and production method. In this respect, duckweed must be selected and used as animal feed according to the nutritional and physiological requirements of the livestock.

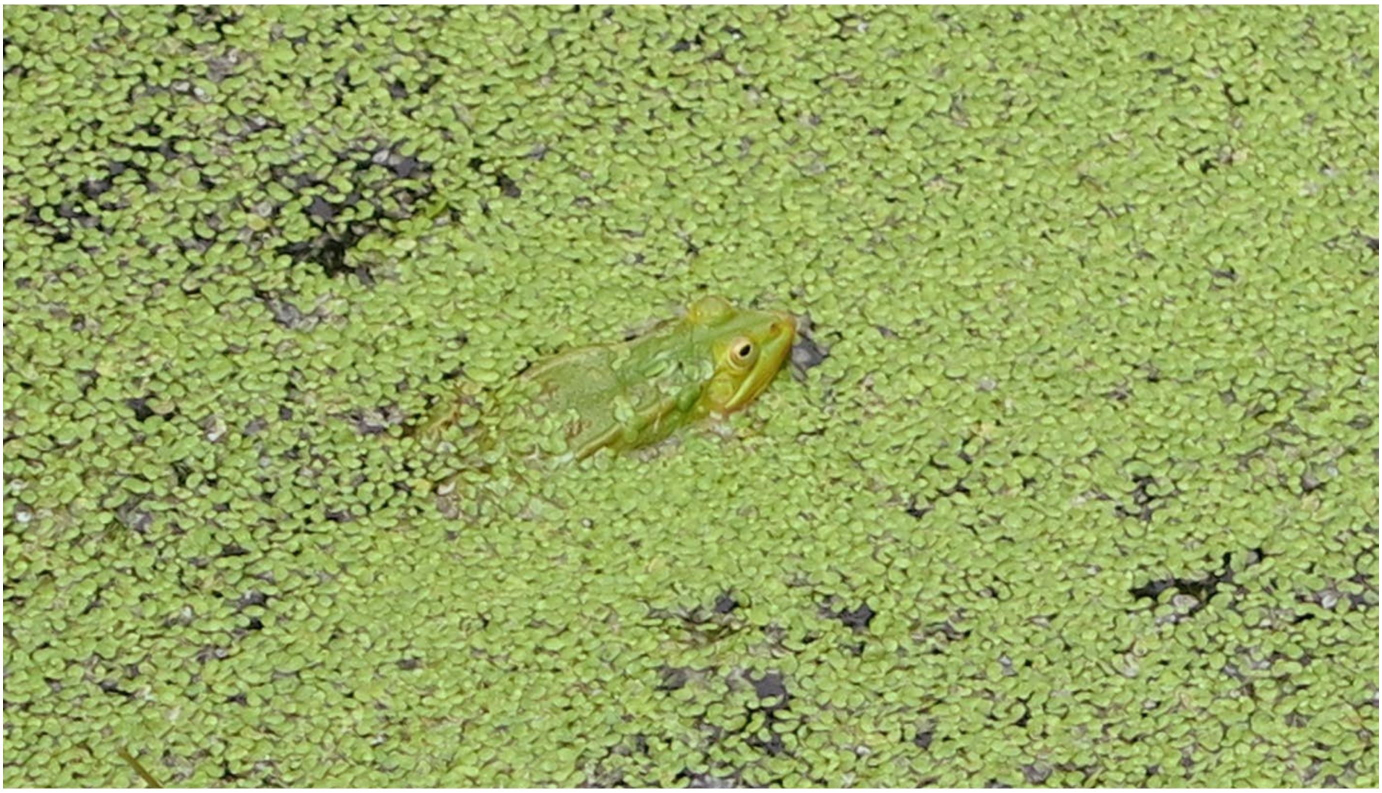
One possible advantage of duckweed, which has not yet been systematically investigated, is the low proportion of so-called antinutritive factors (ANF), i.e. substances produced by plants to protect them from being eaten. In higher concentrations, these lead to significantly reduced feed and nutrient utilisation, as is the case with untreated soya, for example.[15] Nevertheless, certain species of duckweed contain antinutritive substances, meaning that they cannot be fed without restriction.

The duckweed species *Lemna minor* and *Lemna gibba*, for example, contain oxalic acid with the salt component calcium oxalate, which in higher concentrations leads to problems in human nutrition or animal feed.[16] Phytic acid, tannins and cyanides have also been identified in duckweed and are among the ANF. as antinutritive ingredients.[17] Phytic acid in particular has a problematic effect in higher concentrations because it stores phosphorus in a form that is not biologically available for animals and humans and at the same time inhibits the digestion of minerals.

Table 1: Macronutrients of different duckweed species

Duckweed species	*Spirodela polyrhiza* (climate chamber)[6]	*Spirodela polyrhiza* (greenhouse)[6]	*Lemna minor*[18]	*Lemna minor*[18]	*Lemna gibba*[19]	*Lemna sp.*[20]
Crude protein[15] (% DM)	30.6	18.0	36.1	27.1	32.9	18.6
Crude fat (% DM)	*	3.1	8.45	7.15	3.9	1.5
Crude ash (% DM)	19.6	21.8	21.4	19.4	22.1	2.5
Carbohydrates (% DM)	*	*	34.1	46.3	14.8	83.9

DM = dry matter; * Not analysed



Duckweed such as *Lemna minor* contains nutritionally interesting amino acids in relevant concentrations and can be compared with soya or lupin in terms of their nutritional value.

Table 2: Amino acids (as % of crude protein) in duckweed compared to soya and lupins[12]

Duckweed species	***Spirodela polyrhiza*[12]**	***Landoltia punctata*[12]**	***Lemna minor*[12]**	***Lemna gibba*[12]**	***Spirodela polyrhiza* (green house)[6]**	**Soya[21]**	**Lupins[21]**
Crude protein content	25	18	24.5	28	18.0	44.0	34.4
Amino acids							
Alanine	5.4	5.3	5.1	6.0	5.56	*	*
Arginine	4.7	4.7	4.8	4.9	6.78	7.34	11.1
Aspartic acid	7.8	8.1	8.2	10.6	8.5	*	*
Cysteine	0.8	1.1	0.9	0.9	1.11	1.59	1.68
Glutamic acid	9.6	9.5	9.8	10.3	9.22	*	*
Glycine	4.3	4.5	4.6	4.6	4.89	*	*
Histidine	1.6	1.6	1.5	1.6	1.89	2.66	2.53
Isoleucine	3.3	3.5	3.7	3.4	3.67	4.52	4.54
Leucine	6.8	7.3	7.3	7.2	7.39	7.77	7.99
Lysine	4.2	4.1	5.0	4.2	5.11	6.43	5.07
Methionine	1.6	1.6	1.6	1.6	1.72	1.39	0.89
Phenylalanine	3.97	4.5	4.4	4.3	4.50	4.95	4.01
Proline	3.5	4.1	3.8	3.9	4.39	*	*
Serine	4.1	4.0	4.1	4.2	4.39	*	*
Threonine	4.2	4.1	4.0	4.0	4.17	3.93	3.95
Tryptophan	*	*	*	*	1.72	1.39	0.86
Tyrosine	3.1	3.1	3.1	3.1	3.00	3.84	4.44
Valine	4.4	4.6	4.6	4.5	6.17	5.45	4.24

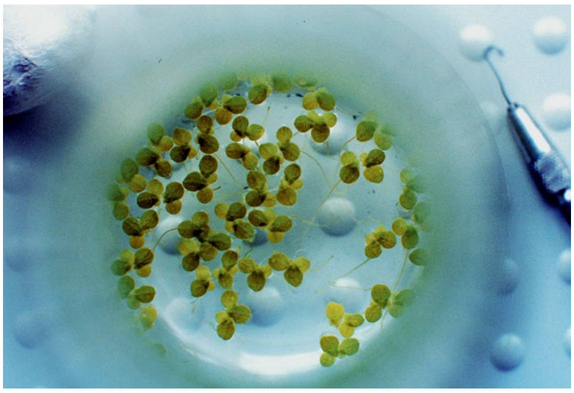
*Not analysed

The challenges of biosecurity

In addition to nutrients, duckweed can also absorb potential pollutants such as heavy metals. For this reason, duckweed is also used in the remediation of polluted waters. However, it also absorbs heavy metals that may be present in the liquid manure used to fertilise duckweed. The amount of heavy metals absorbed depends directly on the concentration in the substrate used. In experiments at FiBL, the substrate (1:10 diluted organic cattle slurry) and the duckweed grown on it were also analysed for individual heavy metals (copper, lead and zinc), which can typically occur in slurry and are sometimes added to the feed or can enter the food chain via e.g. plant protection products. Zinc, for example, is an essential trace substance and is added to pig feed as the physiological requirement often cannot be met naturally. Figure 2 on page 9 shows the decrease in lead, copper and zinc over 3 weeks in the nutrient substrate. However, biomagnification, i.e. the accumulation of the respective heavy metal by the duckweed, must be taken into account, as can be seen from the different concentrations in the µg and mg range.

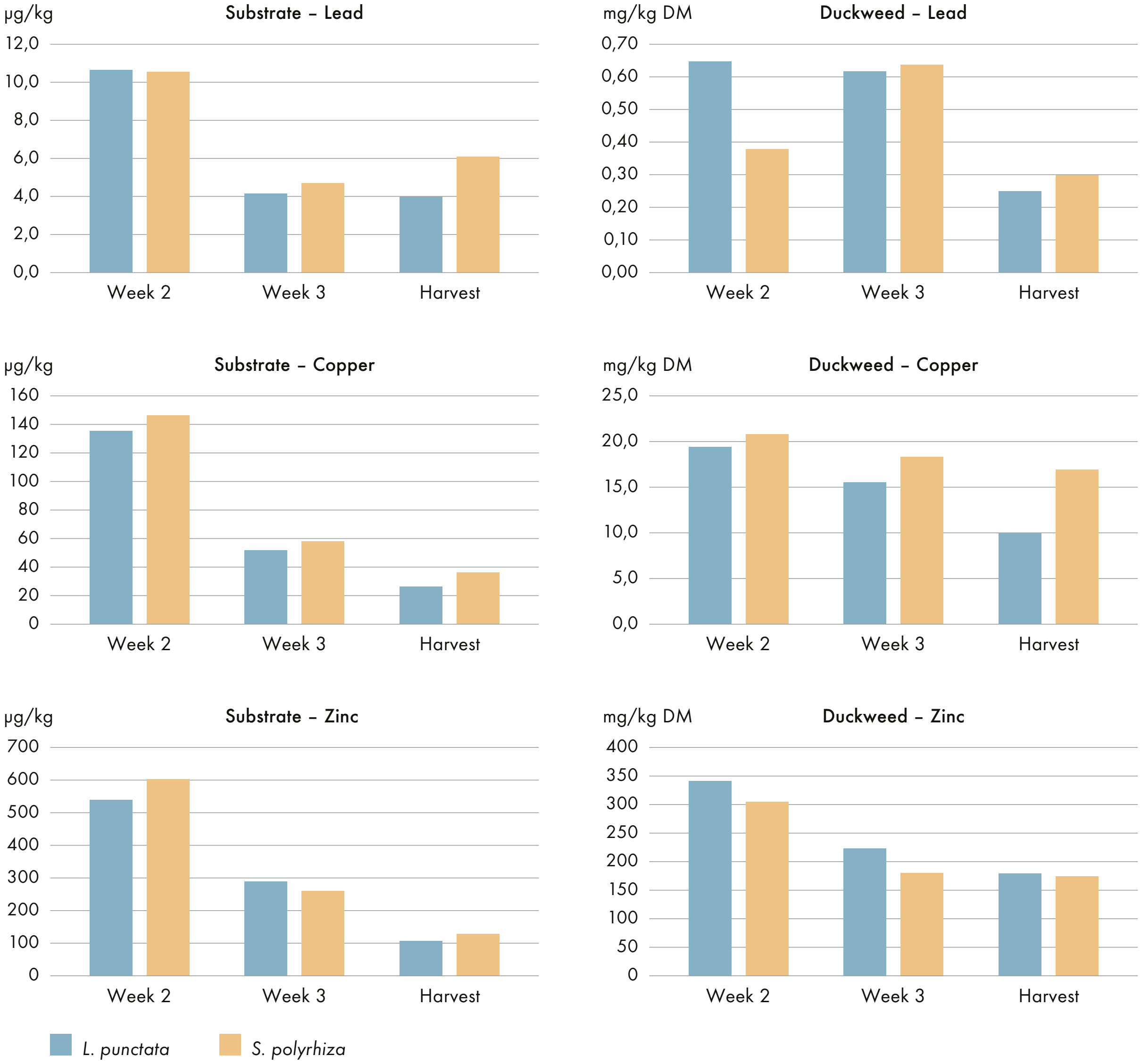
The Swiss Feedstuffs Ordinance (FMBV) specifies clear maximum values for undesirable substances in feedstuffs. The maximum level for lead in green fodder, which could include duckweed, is 30 mg/kg. The concentrations in the harvest of both species of duckweed shown in Figure 2 were well below the maximum permitted levels. The maximum permitted amount of copper in feed differs between animal species. For cattle before the age of rumination, i.e. at approx. 3–4 months, the maximum level of copper is 15 mg/kg, and after reaching the age of rumination is 30 mg/kg. For sheep it is 15 mg/kg, for goats 35 mg/kg, for piglets up to 4 weeks after weaning 150 mg/kg and for older piglets 100 mg/kg. For all other animal species, 25 mg/kg applies. Both types of duckweed, *L. punctata* and *S. polyrhiza*, had copper concentrations of between 10 and 17 mg/kg at harvest. They would therefore be unsuitable as complete feed for cattle before the ruminant age and for sheep. In addition, the difference to the maximum levels is rather small and could be further reduced if the concentrations in the substrate are increased. For pigs, the copper concentrations in both types of duckweed are well below the maximum permitted levels. For all other livestock, duckweed is questionable as a complete feed due to the maximum copper levels almost reached.

The maximum permitted levels of zinc also depend on the type of livestock and are 180 mg/kg for milk replacer feed for calves, 150 mg/kg for piglets and sows and between 120 mg/kg and 150 mg/kg for various fish species. The zinc contents measured in both species of duckweed (175 to 180 mg/kg) were so high that it would be just about permissible if they were to be used as complete feed. If the two duckweed species are mixed with other feedstuffs and processed into pellets, a dilution effect occurs and the copper and zinc contents can be reduced.



The growth of small populations of duckweed can be measured in the laboratory using imaging techniques.

Figure 2: Heavy metal contamination in substrates



Lead, copper and zinc concentrations in the substrate from diluted organic binder slurry (left) compared to the harvested duckweed (right) of the species *Landoltia punctata* and *Spirodela polyrhiza*. No variance is shown as these are pooled samples.

Faeces and the risk of bacterial contamination

Potentially pathogenic microorganisms (primarily bacteria, viruses, parasites) play a role in a duckweed production system for use as feed or food based on animal faeces. While manure is also used in agriculture to fertilise fields, crops grown there rarely come into direct contact with the manure. In contrast, duckweed grows directly on a water-slurry mixture in an agricultural production system. A number of bacteria such as coliform bacteria (*Escherichia coli*, in particular EHEC O:157), clostridia (*Clostridium* spp.), salmonella (*Salmonella* spp.), listeria (*Listeria* spp.) or staphylococci (*Staphylococcus aureus*) can cause serious illness in humans and animals.

The problem of diseases that are transmitted between animals and humans (zoonotic diseases) is more widely recognised now due to the coronavirus (Sars-CoV-2), which is transmitted from animals to humans. While many potentially zoonotic bacteria do not have the same epidemic or pandemic potential as the coronavirus, this issue must at least be taken into account when using manure for duckweed production.

Results from tests

In an FiBL trial with the two duckweed species *Spirodela polyrhiza* and *Landoltia punctata*, the bacterial load caused by E. coli, salmonella and clostridia was observed in a growth substrate with diluted cattle manure. After harvesting, the duckweed was freed from residues of the substrate using a salad spinner. The duckweed was not washed or treated afterwards. No Salmonella was detected in the slurry or on the duckweed during the trial. In the case of *Spirodela polyrhiza*, more coliform bacteria per gram of fresh mass were detectable than on *Landoltia punctata* (approx. 3 times more). In contrast, significantly more colony-forming units of *Clostridium* spp. per gram of fresh mass were detectable on Landoltia *punctata* compared to *Spirodela polyrhiza*. With the exception of Salmonella, the bacterial load in the slurry was generally very high for all bacteria measured. However, the load in the substrate decreased significantly over the course of a week. Duckweed is therefore exposed to bacterial contamination, which depends on the concentrations present in the nutrient substrate supplied. The bacterial load in the nutrient substrate (diluted slurry) of duckweed is related to the health status of the livestock. A further reduction of germs is possible by cleaning the duckweed after harvest.

Antibiotic residues must be taken into account

In addition to contamination by various bacteria, duckweed can also be contaminated by veterinary drug residues and antibiotics. In principle, the growth of duckweed is not affected by high concentrations of antibiotics in the water. However, one study showed that the antibiotic oxytetracycline was passed on to edible fish after they were fed with contaminated duckweed of the species *Wolffia globosa*.[23] If manure from livestock treated with antibiotics is used as a substrate for duckweed, there is a risk that residues will re-enter the food chain. This makes substrate monitoring and quality assurance in manure-duckweed systems very important. Interestingly, various antibiotics can also be inactivated by duckweed (phytodegradation).[24]

Certified organic trout farm in Switzerland.

Test trial with duckweed as a food ingredient for juvenile carp, trout and perch in laboratory aquaria.

Duckweed as food and animal feed

In various Asian countries, duckweed of the species *Wolffia globosa* is sold, such as in Thailand as "Khai Nam", and consumed by people either in powder form or as a fresh vegetable. Compared to terrestrial plants, duckweed has significantly fewer supporting structures. Unlike edible crops on land, duckweed as a floating or swimming plant can do without the stabilising properties of lignification. The proportion of lignin and other indigestible components in duckweed is therefore very low.

Suitability as animal feed

Feed must cover all or part of the nutritional requirements of an animal species, depending on whether the animals have access to other food sources and whether these are available in sufficient quantities. As a rule, the more intensive the animal husbandry, the higher the proportion of complete feed in production. Complete compound feeds are predominantly used in intensive livestock production, where animal numbers are high and natural feeds play no role. The nutrient requirement depends not only on the animal species, but also on other factors. For this reason, a distinction in animal nutrition is often made between complete feeds, which must cover the entire nutrient requirement, and supplementary feeds, which fulfill certain functions or are intended to remedy mineral and vitamin deficiencies. Complete feeds must accordingly be tailored to the animal species and its nutritional requirements. This means of course that the needs of the species must be known.

Although duckweed has a very good nutrient composition and a high proportion of nutrients in the dry matter, in fresh duckweed the nutrient density is very low due to the high proportion of water, which is why it is unsuitable as a complete feed when provided fresh.

Factors on which the nutrient requirements of fish species depend

- Life stage: young animals have a higher protein requirement and older animals have a higher energy requirement, the protein:energy ratio changes accordingly
- Environment: cold or warm ambient temperatures (especially for fish and other cold-blooded animals)

Use of duckweed in aquaculture

Fish farming under Swiss conditions

In Swiss aquacultures, fish production is limited to a few species. Shrimps also supplement the range of species to a lesser extent. Rainbow trout *(Oncorhynchus mykiss)* accounts for around 2000 tonnes of annual production, or around 60 % of the total quantity produced in Swiss aquacultures. The Eurasian perch *(Perca fluviatilis)*, which is produced in recirculation systems, is also important. Other farmed fish species include Atlantic salmon *(Salmo salar)*, Siberian sturgeon *(Acipenser baerii)*, pike-perch *(Sander lucioperca)*, whitefish (*Coregonus* sp.), brown trout *(Salmo trutta)* and carp *(Cyprinus carpio)*.

Only a few of the freshwater fishes native to Switzerland are pure herbivores. During juvenile development, the proportion of animal plankton and small crustaceans in the natural diet is usually very high. With increasing age, many fishes specialise in a particular food. Fish are categorised into carnivores, omnivores and herbivores according to their dietary spectrum. The higher the animal-based consumption by a species, the higher its position in the food chain and the higher its trophic level.

Trophic levels in fish
The trophic level roughly indicates the position in the food chain. The lower it is, the more plant-based and less animal-based food is consumed.

Herbivorous or non-predatory fish have a trophic level between 2 and 3, omnivorous fish have a trophic level between 3 and 4 and carnivorous or predatory fish have a trophic level of 4 or higher.

Low trophic level fish

Fish of a lower trophic level include the most important group kept in aquaculture worldwide: carps. With a total of 28.8 million tonnes, they account for around 53 % of global fish production (54.3 million tonnes). In addition to carp, cichlids such as the Nile tilapia are also of great economic importance.

Both are good utilisers of plant food and are also suitable for organic and sustainable aquaculture. The important carp species in aquaculture generally have a trophic level between 2 (grass carp) and 3.1 (common carp). Tilapia are known as algae and growth eaters and, with a trophic level of 2, would be ideally suited for feeding with duckweed.

Depending on the fish species and various factors, the proportion of duckweed in the feed must be adjusted. The nutrient content and nutrient availability as well as any inhibitor content play an important role in adjusting the feed concentration. Table 3 on page 13 shows corresponding fingerling and grow-out trials with carp *(Cyprinus carpio)*.

High trophic level fish

There are hardly any studies on duckweed as a fishmeal substitute for typical predatory fish. On one hand, predatory fish of a high trophic level make up a small proportion of farmed fish globally, and on the other hand, duckweed has been of little importance as a plant-based feed component to date. In the past, salmon farming required the largest quantities of fishmeal. More recently, however, soya has been increasingly used and is also being researched as a feed component. The use of duckweed as part of feed formulations is therefore conceivable and could be increasingly tested on predatory fish.

To this end, FiBL conducted various feeding trials with duckweed in fry and juveniles of rainbow trout and perch (Table 3). At the ZHAW, grow-out with duckweed was also trialled on rainbow trout. Due to unsatisfactory results from the FiBL feeding trial with perch, it was decided not to continue with a fattening trial.

Table 3: Results of various studies on the use of duckweed in the feed of carp and tilapia, in each case in comparison with a duckweed-free reference feed

Test conditions			Results		Fish species
% fishmeal (FM) in the reference feed	% FM protein replacement or concentration in the feed	T/F	Growth	Feed utilisation	
40	15	T	+–	+–	Carp (0.7 g) [25]
	30	T	+–	+–	
	45	T	+–	+–	
	15	F	+–	+–	
	30	F	–	+–	
	45	F	––	–	
40	23	T	+	+	Carp (47 g) [26]
	26	F	–	+	
35	20	T	+–	+–	Tilapia (89.1 g) [27]
	40	T	–	–	
	20	F	+–	+–	
	40	F	–	–	

Table 4: Results of two studies on the use of dried or fermented duckweed in the feed of rainbow trout *(Oncorhynchus mykiss)* and perch *(Perca fluviatilis)*

Test conditions			Results		Fish species
% fishmeal (FM) in the reference feed	% FM protein replacement or concentration in the feed	T/F	Growth	Feed utilisation	
35	12	T	+–	+–	Trout (fingerling, 1.49 g)[28]
	24	T	–	+–	
	35	T	––	–	
	12	F	+–	+–	
	24	F	–	–	
	35	F	–	–	
40	12	T	–	–	Perch (fingerling, 3.52 g)[28]
	24	T	––	––	
	35	T	–––	–––	
	12	F	–	–	
	24	F	––	––	
	35	F	–––	–––	
66.6	6.25 (concentration)	T	–	+–	Trout (fry, 0.278 g)[6]
	12.5 (concentration)	T	–	+–	
35	26.6 (concentration)	T	–	–	Rainbow trout (104 g)[26]
	26.6 (concentration)	F	–	–	

T = dried duckweed, F = fermented duckweed
+ better than reference, - worse than reference, +- as good as reference

Further areas of application for duckweed

Feed for poultry and pigs

In addition to being used as feed in aquaculture, duckweed can also be used as feed for other farm animals such as pigs, poultry or cattle. Although the macro- and micronutrient requirements differ between the various animal species and life stages, the basic requirements are similar. In poultry, duckweed has been tested as a feedstuff in several studies. As early as the mid-1990s, duckweed of the species *Lemna gibba* was fed to laying hens (TOPAZ and HyLine Leghorn). The eggs from hens with 15 and 25 % *L. gibba* in their feed not only had a higher protein content but also a stronger pigmentation of the yolk.[19]

The suitability of duckweed for feeding pigs has only been tested to a limited extent to date. As part of a study, commercial duckweed protein concentrate was tested on young pigs for digestibility with regard to energy, phosphorus and amino acids. No major differences were found compared to fish meal, which was also used to feed young animals in the trial.[29]

Duckweed for bioenergy and biomining

In future, duckweed could also be considered as a bioenergy plant for the production of bioethanol. The advantage of this use is that the protein content and, to a certain extent, biosafety play a rather subordinate role. On the other hand, the starch content is a decisive criterion for suitability as a source material for bioethanol production. The starch content of duckweed depends on various factors, but is found to be higher with a lower growth rate and protein content.[30]

Duckweed can also be used to clean up heavily polluted wastewater, e.g. from mining, in order to absorb heavy metals.[31] That is why its use in the field of "phytomining" or "biomining" is being discussed. This makes duckweed particularly interesting in connection with the recovery of phosphorus from urban wastewater or even from livestock manure. In laboratory tests, duckweeds such as *Lemna minor* or *Lemna japonica* were able to absorb phosphorus even at very low temperatures (8 °C) and with only 6 hours daylight.[32]

Although growth was suboptimal under these conditions, phosphorus uptake was comparatively efficient. The phosphorus is recovered by extracting it from the ash after incinerating the duckweed.

Duckweed on 4000 square metres of an organic pangasius farm in Vietnam

Conclusions

Duckweed is a valuable source of high-quality protein with good digestibility. It therefore offers considerable potential for animal nutrition, but there are still challenges in production, particularly in the area of biosafety. Biosafety depends heavily on the substrate used. However, there are legal difficulties for the cultivation of duckweed as animal feed if it is grown directly on diluted liquid manure. The high water content of the fresh biomass reduces its shelf life, which is why drying or other processing is necessary for use as animal feed.

Ensiling or fermenting is another option. When fed to carp and trout, fermented duckweed has led to similar results compared to dried duckweed. The results of the work carried out at FiBL and the ZHAW, as well as in the context of international projects, emphasise the potential of duckweed as a feedstuff. However, further research projects are needed to answer pending questions.

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Imprint

Published by
Research Institute of Organic Agriculture FiBL
Ackerstrasse 113, P.O. Box 219, 5070 Frick, Switzerland
Tel. +41 (0)62 865 72 72
info.suisse@fibl.org, www.fibl.org

Author: Timo Stadtlander (FiBL Switzerland)

Editors: Jeremias Lütold, Vanessa Gabel (both FiBL Switzerland)

Design: Brigitta Maurer (FiBL)

Photos: Timo Stadtlander (FiBL Switzerland): p. 1,3,4,9, Marion Nitsch: (https://www.nitsch.ch/) p. 2, Veronika Maurer: p. 8, Thuy An Do p. 14

FiBL article number: 1765

DOI: 10.5281/zenodo.10977231

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