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# No Longer Crawling: Insect Protein to Come of Age in the 2020s

## Scaling up Is on the Horizon

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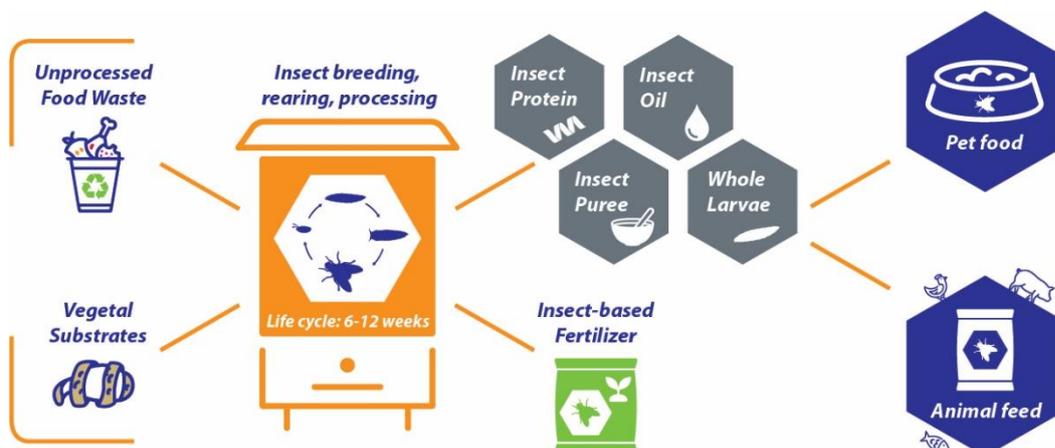
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The demand for insect protein, mainly as an animal feed and pet food ingredient, could reach half a million metric tons by 2030, up from today’s market of approximately 10,000 metric tons. While the sustainability aspects and functional benefits support demand growth, high costs and prices, the current limited production capacity, and legislation are the main factors limiting growth of insect protein. Reflecting these opportunities and constraints, we believe the strongest future demand for insect protein lies in the aquafeed market. Beyond inclusion in aquafeed formulas, a range of R&D-driven opportunities will create additional areas of future success for this new industry.

## Insects: A Circular Economy Solution to the Protein Challenge

Insect-based nutrition is emerging as a whole new category in food and feed systems. It has the potential to bring new value-added propositions based on its nutritional, functional, and environmental benefits: 1) Insects have a high protein content (50% to 80% dry matter basis); 2) When used as a feed ingredient, insect proteins bring health benefits to fish, pets, and other animals; 3) Insects can help to build circular food systems as they can upcycle low-value agri-food material, including former foodstuffs, wastes, and residues, into high-value proteins, oils, and other ingredients; 4) When local, underutilized resources are used as feed substrates to farm insects, not only is the food-waste challenge tackled, but a local feed production system is created and the feed supply chain is shortened; 5) Insects are part of the natural diet of most animals; and 6) Insect farming is a highly efficient protein production system with a small environmental footprint, requiring less water, less land, and less production time compared with other species.

Figure 1: Insects contribute to a circular economy upcycling of low-value agri-food materials into high-value protein and other applications



Note: The figure is for illustrative purposes to show the circularity potential of insect farming. Feedstocks and end-markets illustrated here are not yet fully approved by regulators. Further information can be found in Figure 3  
Source: Rabobank 2021

In our view, insects have a larger potential as feed ingredient than as direct consumer food in the next decade. Although edible insects tick all the boxes from a nutrition, health, and sustainability point of view, current consumer acceptance is still low in developed countries, for both whole and processed insect-based foods. Their market share is negligible, and opportunities, at least for now, are limited. Hence, going forward, we focus on the potential of insect protein as an animal feed and pet food ingredient.

## High Costs and Legislation Hinder Scaling Up

Although there are many positives that support the growth of insect protein as a pet food and animal feed ingredient, some major challenges also exist that currently prevent the development of the insect farming industry from taking off, such as limited scale, high costs and prices, and legislative barriers.

### Aquafeed Needs Insect Protein in Bulk

The industry's first challenge is the lack of scale. Current volumes of insect protein are at around 10,000 metric tons globally, led by a few larger-scale producers and many small-scale players. After producing smaller quantities at test facilities, many of the leading industry players (e.g. mealworm producers, such as Ynsect in France, or black soldier fly [BSF] farmers, such as UK-based AgriProtein, Netherlands-based Protix, and France-based InnovaFeed) have built larger facilities to produce at scale. Some of these plants are already working at, or close to, full capacity, and some have yet to be opened – most of these players have global plans to build multiple production facilities.

Currently, pet food is the largest market for insect proteins, followed by the aquafeed market. At least currently, the demand for insect protein seems higher than its supply. Aquafeed companies state that the lack of available volume is one of the key reasons for not using insect proteins, as they deal with large quantities and production runs. Some pet food companies also state that the market could absorb more if the availability were higher.

### Still Too Expensive for Mainstream Use

High costs and thus high prices are limiting the demand for insect protein. Currently, the price of insect protein ranges between EUR 3,500 to EUR 5,500 per metric ton, which is significantly higher than fishmeal and soy protein. Fishmeal prices historically mirror the volatilities in supply. In the last five years, they have moved between USD 1,200 to USD 2,000 per metric ton (see Figure 2).

Figure 2: Fishmeal is the price-setting protein source in the aquafeed market



Source: UB Comtell, Rabobank 2021

The sustainability benefits that insects can offer seafood products – such as decreasing the dependency on marine ingredients – combined with marketing of the final product, can justify relatively higher prices. If there are also well-understood functional benefits in addition to the nutritional benefits, their use in aquafeed would increase. Largely proven functionalities, such as supporting the gut and immune health of fish and antioxidant features, can help insects to achieve a price premium.

## Legislation Will Not Be a Barrier for Long

The legislation governing feedstocks and end markets for insect farming varies globally. Within the EU, the types of feedstock that can be used to rear insects are limited (see Figure 3). For instance, former food waste that includes fish and meat or catering waste and slaughterhouse products are not authorized as insect farm feedstocks. However, the legislation could change. The insect industry expects unprocessed former food waste that includes meat and fish and undervalued former foodstuffs (e.g. containing unavoidable packaging remnants) to be approved as insect farm feedstocks by 2022. This would add to circularity through the upcycling of resources that would otherwise be discarded. It would also bring more flexibility and cost advantages to the insect industry, as utilizing catering waste and other waste that includes meat and fish could be an opportunity for negative feed costs.

Figure 3: Further widening of EU legislation expected in both feedstock sources and end markets

Feedstock	Regulatory approval	Insect production	Target species	Protein	Fat	Live larvae*	Whole (dried or frozen)*
Vegetal substrates	✓			Pet food	✓	✓	✓
Unprocessed former food waste: dairy & eggs	✓	Aquafeed		✓	✓	✓	✗
Unprocessed former food waste: meat and fish	✗	Poultry Broiler		✗	✓	✓	✗
Catering waste & slaughterhouse products	✗	Poultry Layer		✗	✓	✓	✗
Animal manure	✗	Swine		✗	✓	✓	✗

Note: \*permitted under national legislation in certain EU member states  
Source: IPIFF, Rabobank 2021

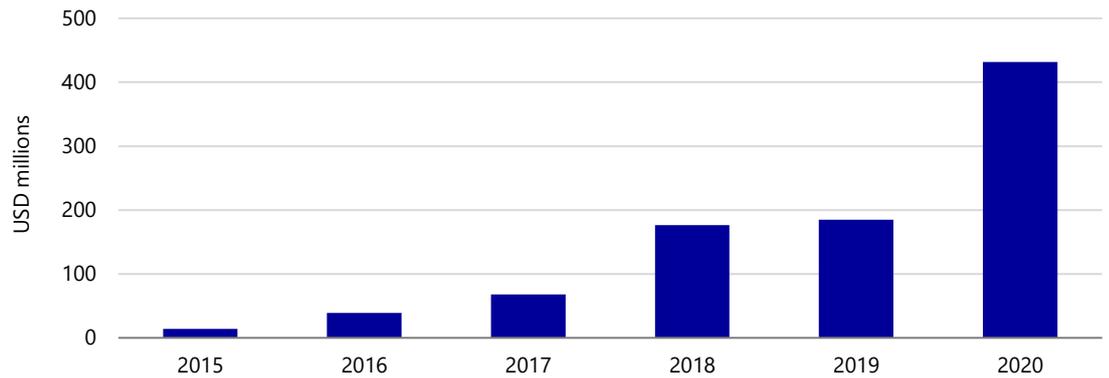
Another expected change is that in the end markets. Currently, in the EU, insect protein can only be used as pet food and as an aquafeed ingredient, but not as swine or poultry feed. On the other hand, insect oils and live larvae are already authorized for use across all markets. There is no harmonized legislation that regulates the use of whole insects as pet food and in specialized markets (e.g. exotic animals, fishing bait) in the EU. The rules vary per country, and insects are only authorized in these markets in a few EU countries. The future authorization of insect protein in poultry and swine markets is being discussed, and approval is expected by 2022. Although we think the swine market is a small potential market for insect protein, we believe poultry feed offers considerable opportunities.

Legislation in North America is different. In the US, the Food and Drug Administration regulates animal feed and pet food, but there are differences between states regarding the regulation of insects as animal feed. Insects should be reared on feedstocks approved by American Feed Control Officials. Pre-consumer waste and other by-products are authorized as feedstocks. In Canada, insect farm feedstocks can consist of pre-consumer food waste if approved by the Canadian Food Inspection Agency. Insect meal is not yet approved as a pet food ingredient in the US but is approved as a poultry and salmonid feed ingredient. In Canada, the application of insect meal is authorized as a pet food ingredient, but not yet as an aquafeed and poultry feed ingredient. In both markets, legislation changes are expected throughout 2021.

## No Lack of Investor Appetite

Insects have received significant investment, particularly since 2018, enabling insect companies to build larger-scale production facilities. Capital inflow to the sector accelerated after the EU authorized the use of insect proteins as an aquafeed ingredient in July 2017 (see Figure 4). Insect investments in 2018 were around 45% higher than the sum of investments received in the previous three years. Currently, the total of disclosed investments in insects is nearly EUR 1bn. The largest disclosed investments were received by Ynsect and by InnovaFeed in late 2020.

Figure 4: The exponential increase in capital flowing to insect farming companies



Source: Crunchbase, Dealroom, Rabobank 2021

The insect companies that have received the largest investments stand out for their business models, partnerships, or rapid geographical and product suite expansion. For instance, InnovaFeed has entered a strategic partnership for salmon and shrimp feed with Cargill and has announced a production plant in the US through a partnership with ADM. Protix has extensive engineering and R&D programs, which resulted in achieving full-scale capacity of its production facility in Bergen op Zoom, the Netherlands. Skretting (Nutreco’s aquafeed division) is a large aquafeed player and has committed to insect proteins with several companies, including Protix and Ynsect. AgriProtein continues to strive for global expansion while establishing partnerships at the same time. Other players have also indicated and communicated significant investments and growth steps.

## Scale Is Coming to the Six-Legged Livestock Sector

By 2030, we estimate a global market potential of up to 500,000 metric tons for insect protein as a pet food and animal feed ingredient. We constructed a model to assess the potential market for insect protein, assuming no supply or legislative constraints. We considered three stages out to 2030: a scale-up phase, a wider-use period, and the maturity phase (see Figure 5). We believe that in the scale-up phase there won’t be a sharp decline in the price of insect protein, so we expect prices to range from EUR 3,500 to EUR 5,500 per metric ton. However, we expect prices to drop by EUR 1,000 per metric ton after the industry completes the initial scale-up phase, and by another EUR 1,000 per metric ton when the sector reaches maturity.

Figure 5: A market potential of half a million metric tons for insect protein is possible by 2030

		Animal feed					
		Total	Pet food	Aquaculture	Poultry - Layers	Poultry - Broilers	Piglets
Estimated market size (metric tons)	Scale-up phase: EUR 3,500–EUR 5,500/metric ton	120,000	65,000	20,000	20,000	10,000	5,000
	Wider-use period: EUR 2,500–EUR 3,500/metric ton	200,000	85,000	55,000	30,000	20,000	10,000
	Maturity phase: EUR 1,500–EUR 2,500/metric ton	500,000	150,000	200,000	70,000	50,000	30,000

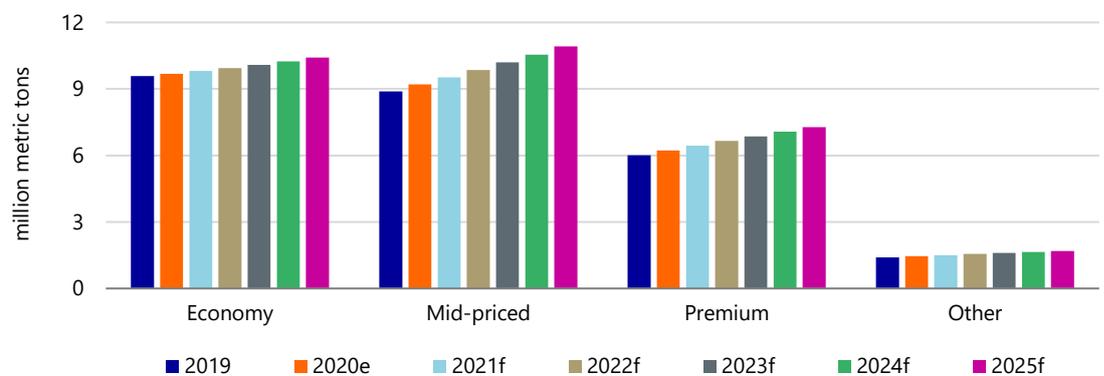
Source: Rabobank 2021

## Pet Food Is Currently the Largest Market

Currently, pet food is the largest market for insect protein and will remain one of the largest. We forecast the market for insect protein as a pet food ingredient to reach 150,000 metric tons globally by 2030. Several factors support the growth of insect protein as a pet food ingredient: 1) growing premiumization and the humanization trend in the pet food market as pet owners increasingly give their pets more natural and high-protein meals and treats; 2) sustainability benefits of insect protein for environmentally conscious consumers; and 3) insects have hypoallergenic features, which is particularly important for cats and dogs with sensitivities and allergies.

Pet food formulated with insect protein is currently placed in the premium and specialty segment of the market, which is set to grow (see Figure 6). Although these products are priced with a premium, most pet owners are willing to pay higher prices if their cats or dogs have allergies and require specialty foods.

Figure 6: Currently, premium pet food is about a quarter of the total market and is set to grow



Source: Euromonitor, Rabobank 2021

Currently, the pet food market can justify the high prices of insect protein due to the functional and marketing benefits. As prices stay relatively high in the initial scale-up phase, in our view, developed countries will drive the demand for insect-based pet food. As insect protein prices come down, we believe the number of pet food players formulating feed with insect protein will increase and niches will also emerge in other parts of the world. However, in the mature stage, we do not expect that pet food will be a leading volume driver, as it is a smaller industry than animal feed. The humanization trend could also be a potential challenge for insect-based pet food – if some pet owners are not comfortable with the idea of eating insects themselves, they may be reluctant to feed insects to their pets.

## A Role in Aquafeed Is the Key to Scale

By 2030, we estimate a global market potential of up to 200,000 metric tons, or 40% of the insect protein market and representing less than roughly 1% of the global aquafeed market in today's volumes.

Only a few thousand metric tons of insect proteins are used in aquafeed today. Insect proteins have proven nutritional qualities for fish – to be expected as insects are a natural food source. But at the current price level, excellent nutritional qualities alone are not enough for the widespread use of insect proteins. The initial use of insect proteins has been as a niche ingredient, providing sustainability and marketing credentials to the final products (fish or shrimp). As there is a need to reduce both fishmeal and soybean meal for sustainability reasons, this is a valid role for insect proteins. This is a market concentrated in North America and Europe, and while it is a growing and relevant niche market, it is ultimately limited and will only be the first step toward scaling up.

The second phase of growth for insect proteins and other insect-derived products will be based on the functional properties of insects. There is increasing research evidence that the inclusion of insect proteins has some positive features beyond nutritional value. One of these is palatability. Insects are part of the natural diet of fish and shrimp – insect proteins and oils have a smell and taste that are attractive to fish and shrimp and can increase appetite. Moreover, research suggests that gut health for certain species can be improved by including insects in the diet. High-value freshwater species, such as eels and sturgeon, which in the wild are largely insect and crustacean predators, especially benefit from having insect protein in their diet. It is likely that feed for these species, and other freshwater catfish, trout, and smolt (the juvenile, freshwater stage of salmon), will be where insect proteins have the highest initial benefit if included in the diet. Finally, and probably less well-documented in current research, is the antioxidant function of insect proteins. Insect proteins are produced continually in highly controlled environments, with a short value chain. The larvae are converted into protein meal and oil immediately after harvesting. This means that these are high-quality products with no degradation of the proteins.

In this wider-use phase, insect proteins will be used alongside fishmeal and soybean meal but in relatively small inclusion rates, sufficient to achieve their functional properties. As such, their price will not be a reflection on what they replace but what they contribute to the overall value proposition of the feed. This should allow profitable scale-up. However, it is clear that not only is more research needed, but the functional properties will need to be demonstrated to the aquafeed industry in a commercial setting. Although there are some very promising indications, this will take time.

Beyond 2030, we expect scale to allow the cost level to be more comparable with fishmeal. By this time, legislation will also not be an issue, allowing a more diverse range of raw materials to be used. Even in this period, we do not expect to replace fishmeal or soybean meal. But insect proteins and oils will be new raw material categories, which, in combination with fishmeal, soybean meal, or other novel ingredients, will create better performing aquatic feeds with lower environmental footprints. By this time, we expect the sector to have a wide range of protein sources, as insect proteins will differentiate depending on the species as well as the feedstock that has been used to feed the larvae. Some insect proteins will be high-end products used as starter feeds, broodstock feeds, or feed for high-value species, while others will be used more as bulk proteins for carnivorous or even omnivorous aquatic species. Needless to say, this is very much a long-term ambition for the insect farming industry, and considerable investments, R&D, and market development are needed to get there. Having said this, we do see a path to scaling up for insect proteins in the aquafeed sector.

## Layer Hens and Backyard Poultry Show Potential

Our estimations show that as the sector reaches a certain maturity, the demand for insect protein as layer hen feed could reach up to 70,000 metric tons globally. Although the potential in broiler feed is more limited, due to the large market size of compound broiler feed, insects could still create a market of up to 50,000 metric tons.

In poultry feed, the largest potential lies in layer hens. The egg market allows for differentiated concepts and categories, such as free range, organic, omega-3 added, etc., which gives space to market insect-fed eggs. We believe the potential is more limited for broilers, due to the high price point of insects compared to soybean meal. However, some niche concepts based on insect feed, similar to organic chicken, are possible in developed countries. For example, including whole insects in poultry diets allows animals to show natural behavior and accordingly increases animal welfare. In addition, backyard poultry, particularly in North America, is also a market for insects, driven by similar dynamics as the pet food industry.

## Questionable Whether Insect Proteins Will Play a Role in Swine Feed

A global market of up to 30,000 metric tons is possible for insect proteins as a swine feed ingredient. We consider the swine market the smallest addressable market for insect protein due to the specific swine market dynamics and the much higher price of insect protein compared to soy. There could, however, be small niche or premium markets once insect protein prices decrease.

### Insect-Based Nutrition Bringing Many Value-Added Applications

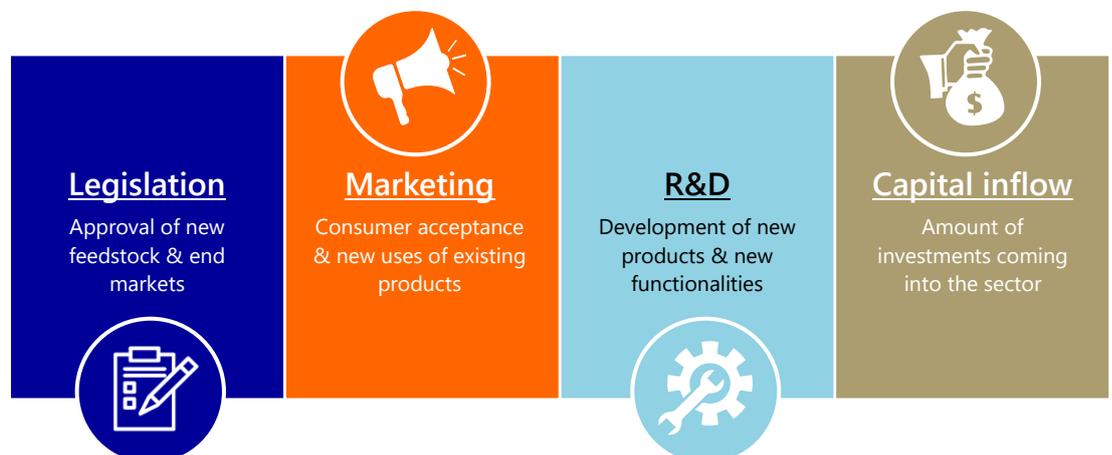
Highly relevant for the future profitability of the industry is the potential for insect-based specialty ingredients. Insects and their larvae are not a single commodity product such as, for instance, sugar, which is essentially one molecule. They are not even one single animal but a new group of domesticated species. At the infancy of the industry, proteins sold in pet food, aquafeed, and perhaps poultry feed will indeed drive scale. With ongoing R&D, we expect the development of new insect products with specific functions for gut health, palatability, disease resistance, and perhaps even uses beyond feed, such as in pharmaceutical products for example.

A parallel can be drawn with the pig industry. While production of pork chops is the driver of volume for the industry, every part of the pig is used, and speciality ingredients such as gelatine, cysteine, and stearic acid are also made from the pig carcass but have a far higher price per kilogram than pork meat. One avenue that insect research is looking into is the potential to develop powerful antibacterial, antifungal, and anti-pathogenic substances from farmed insects. In natural settings, insects are animals that can survive and thrive in some of the harshest pathogenic environments, and they have evolved to feed on decaying organic matter. Clearly considerable R&D is needed to develop this part of the industry.

## What Will It Take to Exceed One Million Metric Tons?

We believe 500,000 metric tons by 2030 will represent a turning point for the insect industry. The insect industry is on a path to increase scale, backed by investments and partnerships. Efficiency gains due to increasing technology, automation, improvements in genetics, and legislative changes will also enable costs to decrease. After reaching half a million metric tons, it will get easier for the industry to expand supply. From that point on, it will take much less time to double or even quadruple production volume and exceed one million metric tons. The pace of acceleration would depend on R&D, legislation changes, capital inflow to the sector, and marketing (see Figure 7). The developments of these factors will determine the speed of growth. It might take the industry a few years, or more than five years, to expand supply from half a million to over one million metric tons, depending on the progress made on the growth factors.

Figure 7: Four main factors influence the pace of growth of the insect industry



Source: Rabobank 2021

On the way to reaching scale, insect farmers also need to further prove the functionalities of insect proteins, continue to work closely with legislators, and build consumer awareness of the unique properties of insects to support future demand. These steps need to be achieved to move insects from being used as a marketing tool in niche markets to a mainstream ingredient that is valued for its functional benefits. These steps would also determine the pace of growth the industry experiences.

## **Additional Risk Factors Should Be Addressed**

Currently, the insect industry consists of many small and a few large companies. On the way to scaling up, design of the plant will be a critical success factor for climate control and to prevent transmission of pathogens and other contaminants. From breeding to hatching, rearing, and processing, a controlled environment under one roof is necessary to maintain production safety. As in every monoculture farming industry, insect farming companies that achieve food and feed safety will be best placed to gain regulatory support for larger-scale production.

Without demand from the aquaculture industry, insect proteins would mainly be used in niche markets of pet food, followed by layer hens – both markets are smaller than the aquafeed market. Achieving scale without decreasing prices would mean less demand from the aquafeed industry and could create an oversupply risk.

In addition, although the current potential of insect-based foods for human consumption is limited, in our view, consumers are generally open to insect-fed animal protein and pet food. However, there could be a small group of consumers who are reluctant to feed their cats and dogs with insects if they are not comfortable with the idea of eating insects as food themselves. In the long term, prospects also depend on increasing adoption by the consumer. The number of consumers knowledgeable about insect farming and the benefits of insects is currently limited. Clear communication and education on the unique qualities of insects should improve consumer acceptance of insects as feed and food ingredients.

## **Future Demand Largely Depends on Aquafeed Markets, but More R&D Is Needed**

Decreasing costs and prices are key to increasing the demand for insect protein, particularly in aquafeed markets. Aquaculture is potentially the largest addressable market for insect protein, but it is highly sensitive to the ratio of price and performance, as all feed markets are. To ensure future success, insect farming companies need to create a value proposition that positions insect protein as being competitive to fishmeal in the feed formula, not to fully replace it but to be another relevant component and a tool that can further optimize the feed formula.

In addition to this value proposition, the clear benefits of insects as an aquafeed ingredient should be further demonstrated. Several trials and tests of the functional benefits of insect protein in fish and shrimp diets are promising, showing a positive impact on gut and immune health, offering good palatability and antioxidant features, decreasing feed conversion ratios and mortality, and fulfilling the nutritional requirements in the juvenile stage and in broodstock animals.

Lastly, as we pointed out, there is great potential to develop specialized ingredients and products, likely even beyond feed and human food ingredients. This is potentially the most profitable part of this new industry. Considerable R&D will be needed to achieve all of this.

# Imprint

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