



OPEN ACCESS

Mapping the teaching of aquatic animal veterinary medicine in the European Union and European Free Trade Area

Despoina Iatridou,^{1,2} Laura Pohl,³ Nancy De Briyne,² Dušan Palić,⁴ Jimmy H Saunders,⁵ Ana Bravo^{3,6}

To cite: Iatridou D, Pohl L, De Briyne N, *et al.* Mapping the teaching of aquatic animal veterinary medicine in the European Union and European Free Trade Area. *Veterinary Record Open* 2018;**5**:e000309. doi:10.1136/vetreco-2018-000309

Received 8 August 2018
Revised 5 October 2018
Accepted 30 October 2018



© British Veterinary Association 2018. Re-use permitted under CC BY-NC. No commercial re-use. Published by BMJ.

¹Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium

²Federation of Veterinarians of Europe (FVE), Brussels, Belgium

³European Association of Establishments for Veterinary Education (EAEVE), Vienna, Austria

⁴Department of Fish Diseases and Fish Biology, Faculty of Veterinary Medicine, Ludwig-Maximilians-University Munich, Munich, Germany

⁵Department of Medical Imaging of Domestic Animals and Orthopaedics of Small Animals, Faculty of Veterinary Medicine, Ghent University, Merelbeke, Belgium

⁶Department of Anatomy, Animal Production and Veterinary Clinical Sciences, Veterinary Faculty in Lugo, University of Santiago de Compostela, Lugo, Spain

Correspondence to

Dr Despoina Iatridou; despoina@fve.org

ABSTRACT

Aquatic animal production is the fastest growing food sector globally. Aquaculture and fisheries are very dynamic sectors in the EU and the number of ornamental aquarium pets is increasing. Veterinarians have a fundamental role to play by ensuring health and welfare of aquatic species, productivity and profitability of fish farming, public health and ecosystem conservation. This study investigates how the undergraduate curriculum prepares future veterinarians for such roles by analysing data from the 77 European veterinary education establishments based in EU and the European Free Trade Area. Over 95 per cent of these establishments incorporate teaching in aquatic animal veterinary medicine in their curriculum, while the great majority do so within the core curriculum. Almost half of the establishments provide teaching in aquatic animal veterinary medicine as separate subjects. Many establishments (>40 per cent) provide such training as elective option in their undergraduate curricula or as postgraduate opportunities to enhance Day One Competences. The veterinary education establishments integrating adequately aquatic animal veterinary medicine in their curriculum are evenly distributed in all regions of Europe. Veterinarians are trained and empowered by legislation to assess health of aquatic animals, to diagnose, to prescribe medicines, to notify for diseases and to ensure safe food for the consumers. Veterinary education establishments should encourage training of veterinarians to follow a career in aquatic animal veterinary medicine.

INTRODUCTION

Aquatic animal production is the fastest growing food sector globally, while ornamental aquarium pets and exhibits are increasingly present in our homes and leisure activities.¹ In broader sense, aquaculture refers to farming of aquatic organisms such as fish, molluscs, crustaceans and aquatic plants for human use or consumption, under controlled conditions. Similarly, fishery products include fish, molluscs, crustaceans and other aquatic animals, residues and aquatic plants.

The total production of fisheries in the EU was estimated to be about 6.4 million tonnes of liveweight in 2015,² and estimated number

of ornamental fish was over 12 million in 2016.³ Aquaculture accounts for about 20 per cent of the overall fisheries production in the EU and is extremely diverse in species and production systems. As for ornamental fish, the diversity is much larger as over 300 major species and literally thousands of other species are kept as pets in private homes and in public aquaria.⁴ Within the EU-28 about 137 different species were farmed in aquaculture in 2015,⁵ while this diversification follows a rapidly increasing trend. A special case within the European Free Trade Area (EFTA)⁶ represents Norway, which is one of the top 10 aquaculture producers in the world. In 2016, Norway was the seventh producing and second exporting country worldwide.⁷

Statistics in 2016 and 2017 show that aquaculture and fisheries are very dynamic sectors in the EU as well as worldwide (EUROSTAT reports^{2,5}), while outlooks on growth and development for those sectors for the next 10–15 years are very positive. A study undertaken for the European Parliament's Committee on Fisheries by the European Aquaculture Society, the Federation of European Aquaculture Producers and the University of Stirling Institute of Aquaculture in 2014 forecasts a doubling of production by 2030.⁸ Further to this, sustainable and environmentally friendly aquaculture is highlighted as a priority in the Integrated Maritime Policy's Blue Growth Strategy (EC, 2012, 2017c).⁹ With the EU being the largest importer of fish products in the world and its imports representing a 25 per cent of global imports,⁷ it is evident that there is a lot of potential for EU aquaculture, which despite good intentions and efforts is stagnating, in contrast with increasing growth seen in other regions of the world.

Veterinarians can play a vital role in this sector and contribute to growing potentials

for EU aquaculture. Aquaculture farmers need veterinarians in a similar way that dairy, poultry or pig farmers do.¹⁰ Fish and crustacean farms have similar needs for biosecurity, farming and nutrition, overall health planning and prevention and treatment of diseases in order to be able to produce safe and high-quality products for the consumers.¹¹ Additionally, national veterinary services always need veterinarians to ensure the safety and quality of fish products. Small animal/household veterinarians are increasingly involved in treatment and prevention of ornamental fish diseases, with 10 per cent of practice effort estimated to be related to services to aquatic animal owners and public aquaria.¹² Legislators in the EU acknowledge those needs and place particular provisions with regard to veterinarians' responsibilities in the European legislation.¹³

The aim of our research was to gain a better understanding of the undergraduate veterinary curricula in the EU and EFTA and to investigate whether future veterinarians are prepared to deal with the particular needs of this sector.

Data were collected from veterinary schools—members of the European Association of Establishments for Veterinary Education (EAEVE)¹⁴—via an online questionnaire. Those were supplemented by secondary data collected from the self-evaluation reports¹⁵ of the veterinary schools as submitted at the time of their evaluation by the European System of Evaluation of Veterinary Training (ESEVT).¹⁶ This European evaluation system has been developed in the last 33 years by EAEVE with the collaboration of the Federation of Veterinarians of Europe (FVE).¹⁷

Veterinary curricula in Europe constantly adapt to follow the developments in veterinary science, to comply with the applicable legislation and to meet the needs of the job market. That applies for the whole range of diversity of the veterinary medicine, including the teaching of aquatic animal health. We looked into whether this subject is part of the curricula in the European veterinary schools; whether they are part of the core curriculum or electives; and how much of the teaching time is dedicated to it. In addition, we analysed information on postgraduate courses and programmes offered by those veterinary education establishments (VEE).

MATERIALS AND METHODS

The EAEVE,¹⁴ in collaboration with the FVE,¹⁷ developed and launched a quantitative survey to collect data on implementation of training in minor areas of veterinary medicine by the European VEEs. The survey specifically looked into the teaching of laboratory animal medicine, aquatic animal medicine and bee health as part of the veterinary curricula in the different European VEEs. In this report, we present the findings of the part of the survey related to aquatic animal veterinary medicine.

The survey was addressed to the heads of all 96 European VEEs in 34 countries which are members of the

EAEVE.¹⁴ It was launched at the end of 2013 through SurveyMonkey. The results of the survey were cross-checked one by one with the veterinary schools in the EU and the EFTA at the end of 2016.

Quantitative survey data were supplemented by data from the self-evaluation reports. These self-evaluation reports are prepared by the veterinary schools for the European Evaluation System,¹⁶ and are publicly available documents,¹⁵ containing information on the curriculum, the continuing education and the postgraduate education offered by the veterinary school.

Data were analysed using Microsoft Excel for quantitative analysis and implementation of descriptive research for comparative analysis of certain results, such as subjects and time of teaching.¹⁸ Analysis included data only from VEEs based in the countries of the EU and the EFTA.⁶

RESULTS

A total of 88 out of the 96 VEEs, members of EAEVE,¹⁴ completed the survey. Since a common legislative framework applies for the EU and the EFTA,⁶ we limited our analysis to the data received from the 66 VEEs located in a country of this particular region. Overall, 77 VEEs are established within one of the Member States of the EU and the EFTA. Quantitative data collection was supplemented by secondary data from the self-evaluation reports¹⁵ of 11 VEEs who did not return the survey.

Sixty-eight of the 77 VEEs considered in this analysis hold the status of 'Accredited'/'Approved' by the ESEVT,¹⁹ at the end of 2017, meaning that they meet the minimum standards of quality for training veterinarians.

The analysis of the data from these 77 VEEs shows the following results.

Level and type of training in aquatic animal veterinary medicine in undergraduate veterinary curricula in the EU

Over 95 per cent of VEEs (74 out of the 77) incorporate teaching in aquatic animal veterinary medicine in their curriculum; only two VEEs reported that they do not include any subject in their curriculum, while for one of them we have no data. Thirty-six VEEs offer it as a separate subject and 38 as part of other subjects.

Focusing on the 68 VEEs that hold the status of 'Accredited'/'Approved' by the ESEVT,¹⁶ 32 offer training on aquatic animal veterinary medicine as a separate subject, 34 as part of other subjects and 2 do not include such teaching in their curriculum. The results are displayed in figure 1.

Teaching in aquatic animal veterinary medicine in the 74 VEEs can be obligatory, elective or partly obligatory and partly elective.

As '*obligatory*', we considered the hours that are incorporated in the core curriculum and have to be completed by all the students of the VEE. Where teaching in aquatic animal veterinary medicine is referred to as obligatory training in an elective track of the curriculum, it was interpreted as '*elective*'.

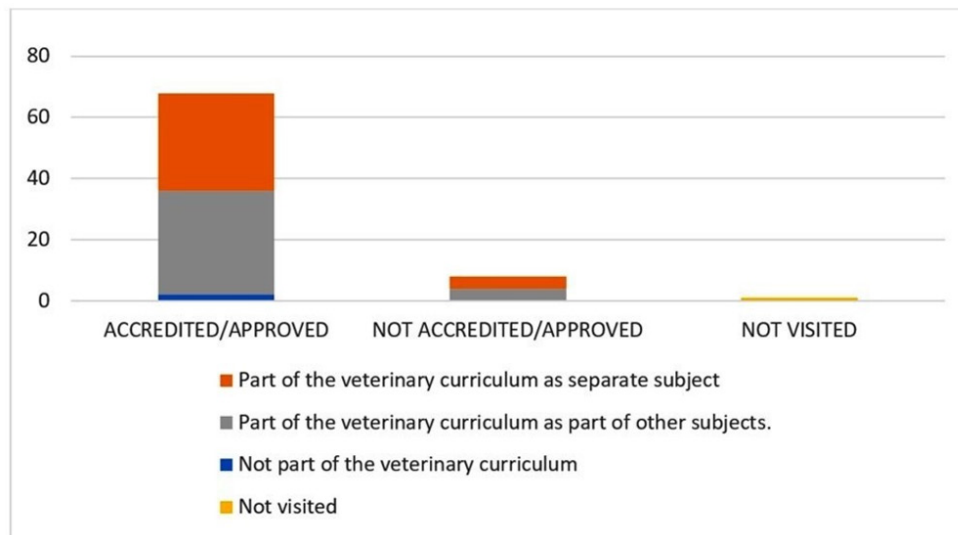


Figure 1 Integration of aquatic animal veterinary medicine in core curriculum of veterinary schools in the EU and European Free Trade Area.

Overall results show that 42 VEEs offer teaching in aquatic animal health and aquaculture in the core curriculum (obligatory), 9 of them offer it as the option to follow by interested students (elective) and 23 VEEs provide it partly obligatory-partly elective (figure 2).

From the analysis of the above results in terms of geographical distribution, we observe that all 27 countries of EU and EFTA that have VEEs established in their territory (figure 3) have at least one VEE providing training in aquatic animal medicine. In most countries, aquatic animal medicine is incorporated in the core curriculum of the majority or all of their VEEs (84 per cent of VEEs). As little as in two countries, their VEEs (one per country) provide such training only as electives.

When the aquatic animal health and aquaculture is part of other subjects, it is included in subjects as follows:

- ▶ Comparative anatomy/physiology.
- ▶ Animal husbandry/zootechnics/clinical sciences in farm animals.
- ▶ Food hygiene/inspection of food of animal origin/veterinary public health.
- ▶ Parasitology/infectious diseases/pathology.
- ▶ Pharmacology/toxicology.
- ▶ Pet fish or ornamental fish is often included in subjects where medicine related to minor species is taught, such as birds, reptiles, amphibians, game animals, fur animals, wildlife or bees.

When aquatic animal medicine is part of subjects such as anatomy, physiology and zoology, it is usually part of the first years of the curriculum. Food hygiene, inspection of food of animal origin and veterinary public health are usually taught later, at fourth to fifth years of the veterinary curriculum.

Separate subjects in the aquatic animal health and aquaculture include:

- ▶ Aquaculture/fishery/fish breeding.

- ▶ Fish diseases and aquatic animal health/fish breeding, fish diseases/pathology and hygiene in aquaculture/fish and shellfish pathology and hygiene in aquaculture/marine mammal health.
- ▶ Biology and pathology of aquatic organisms.
- ▶ Fish biology and pathology.
- ▶ Aquaculture technologies, fish and crayfish diseases and hygiene.
- ▶ Aquaculture, fish hygiene and disease, pet fish disease.
- ▶ Biology and breeding of cyprinid and salmonid fishes (carp, trout).
- ▶ Environmental, viral, bacterial and parasitological diseases of fish. Technique of clinical examination and necropsy.
- ▶ Aquatic environment—interactions between environment and aquaculture.
- ▶ Others.

When aquatic animal medicine is taught as a separate obligatory or elective subject, it is mainly taught in the last years, after third year of the curriculum.

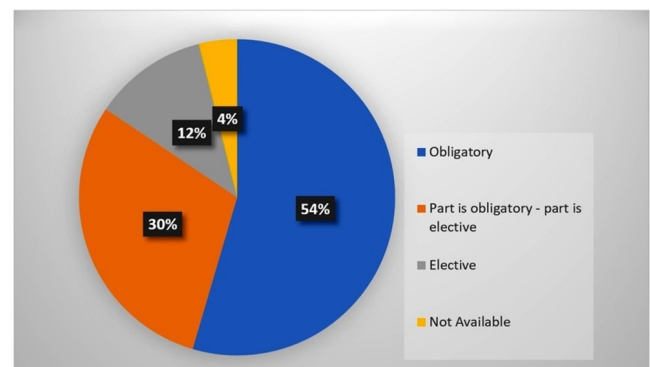


Figure 2 Obligatory versus elective training in aquatic animal veterinary medicine in core curriculum of veterinary schools in the EU and European Free Trade Area.



Figure 3 Distribution of veterinary education establishments in the EU and European Free Trade Area.

Hours dedicated to teaching aquatic animal veterinary medicine in EU and EFTA VEEs

Data on the number of hours dedicated to teaching of aquatic animal veterinary medicine were available from 67 veterinary schools. The total hours (obligatory and elective) dedicated per VEE to teaching in aquatic animal health and aquaculture in the undergraduate curricula in the EU and the EFTA vary from 4 to 200 hours, with the exception of one VEE that offers its students the opportunity to follow an elective track of about 1300 hours. Overall analysis of the total time allocated per VEE to the teaching of aquatic veterinary medicine shows that VEEs providing adequate training in this field (ie, between 50 and 125 hours) are distributed evenly throughout the different regions of the European continent.

The average amount of hours in the core curriculum (obligatory training), as provided by 58 VEEs, was between 25 and 60 hours. [Table 1](#) shows the time that VEEs allocate in the core curriculum for the teaching of aquatic animal health and aquaculture.

From the 32 VEEs, which provide elective courses in aquatic animal health and aquaculture, information on the number of elective hours was available for 31 of them. One VEE dedicates an elective track of about 1300 hours in the last year to the interested students, while data from

the other 30 VEEs indicate a variation in teaching time between 10 and 200 hours ([table 2](#)).

Postgraduate training in aquatic animal veterinary medicine for veterinarians

Data from 69 VEEs show that 30 of them organise postgraduate training on aquatic animal veterinary medicine (30 replied 'Yes', 39 replied 'No' and 8 did not specify).

Table 1 Hours allocated to aquatic animal veterinary medicine in core undergraduate curricula of veterinary education establishments in the EU and European Free Trade Area

Obligatory hours	VEE
3–10	11
11–25	19
26–50	20
50–75	5
75–100	1
>100	2
Total	58

VEE, veterinary education establishment.



Table 2 Time of training in aquatic animal medicine offered as *elective* in veterinary curricula in the EU and European Free Trade Area

Elective hours	VEE
10–25	9
26–50	16
50–75	1
75–100	2
101–200	2
1300	1
Total	31

VEE, veterinary education establishment.

The level of postgraduate education varies from short courses, Master or PhD programmes up to specialisation programmes. The last include either national specialisation programmes or programmes of the European College of Aquatic Animal Health (ECAAH),²⁰ that is, supporting specialist education and recognition at the EU level. These 30 VEEs are established in 16 countries distributed to all different regions of Europe.

From the analysis of data from the 30 VEEs that organise some type of postgraduate training, we note that 29 provide also teaching of aquatic animal veterinary medicine as part of their core curriculum for undergraduates. We also note that the one VEE, which gives the potential of a specialised track in the undergraduate curriculum of about 1300 hours, does not organise any postgraduate courses on this field.

DISCUSSION

Veterinary education in EU and EFTA

Veterinary education in the EU is not fully harmonised. Even though education is the cornerstone for creating qualified professionals in any field, it still falls under the subsidiarity principle.^{21–22} Under the Treaty of Lisbon,²³ education is a policy area where the Union supports, complements or supplements the actions of the Member States (Article 6, Treaty on the Functioning of the European Union (TFEU)), but does not foresee harmonisation of national laws and regulations in this area (Articles 165 and 166, TFEU). Each Member State assumes full responsibility for the organisation of its education and vocational training systems and the content of its teaching. Only for certain professions, the so-called ‘regulated professions’, the EU has set minimum requirements in Directive 2005/36/EC,²⁴ as partially amended by Directive 2013/55/EU.²⁵ For veterinary surgeons, the list of competencies is included in Annex V of the European Legislation and a minimum of five-year training is obligatory.^{24–25} The listing of competencies in Article 38 and subjects in Annex V ensure that the veterinarians will be qualified at their graduation and ready to perform the responsibilities required in the Animal Health Law,²⁶ such as

prevention and biosecurity; examination; early detection of diseases by carrying out proper diagnosis and differential diagnosis to rule out or confirm a disease; prescription and implementation of the right treatment; and raising awareness of resistance to treatments, including antimicrobial resistance, and its implications.

Training in aquatic animal veterinary medicine in EU and EFTA curricula

Our survey takes a closer look into veterinary undergraduate training and presents how the EU VEEs prepare their graduates for roles within the aquaculture sector as well as public health inspection. The results of our survey show that the great majority—96 per cent (74 out of 77) of the veterinary schools in the EU and EFTA—have teaching of aquatic animal health incorporated to a different extent in their curricula.

Data collected directly from the VEEs and/or their self-evaluation reports show that at least 74 out of the 77 VEEs incorporate teaching in aquatic animal health and aquaculture in their curriculum. Although this survey did not investigate how implementation of training in aquatic animal medicine in the veterinary curricula had evolved over the last years, it seems that attention to this particular field of veterinary medicine has increased in the majority of VEEs in the EU and EFTA. More research on this would be beneficial. A remarkable number of schools (36 of 74) provide training on aquatic animal health as a separate subject. The great majority of veterinary schools (65 out of 74) have such training incorporated in core curriculum either as separate subject or as part of other subjects. Only nine schools replied that they have aquatic animal health exclusively as elective.

In the EU and EFTA, Regulation (EU) 2016/429 on transmissible animal diseases, the so-called Animal Health Law of the EU,²⁶ considers aquaculture together with the agriculture sector and aligns terrestrial and aquatic animal health rules. The legislation lays down similar requirements for both sectors and recognises the fundamental role of veterinarians to ensure improved animal health to support sustainable agricultural and aquaculture production in the Union. Referral 47 of the Regulation clearly acknowledges that veterinarians have the education and the professional qualifications attesting the acquisition of the relevant knowledge, skills and competencies necessary, *inter alia*, to diagnose diseases and treat animals. With less than 20 per cent of all fish commodities worldwide being consumed in the country of origin, the trade of seafood presents unique risks and challenges in terms of emerging disease prevention, control and food safety, compared with the risks from terrestrial animals, where over 60 per cent are consumed within the country of origin.^{27–28}

Veterinarians have therefore an important role to play in order to ensure animal health and welfare, sustainable farming, as well as safety of food for humans and public health, in line with the EU Regulations and international standards, such as the World Organisation for Animal

Health (OIE) Aquatic Animal Health Code (the Aquatic Code),²⁹ and the Sanitary and Phytosanitary agreement of the World Trade Organisation (WTO).³⁰

It should be acknowledged that all recognised VEEs require their graduates to gain a basic understanding of the anatomy, physiology and other biological functions of all domestic and food-producing animals, including aquatic species,^{24 25 31} and animals used for other purposes, such as laboratory animals.³² Reading through the responsibilities of veterinarians in aquaculture as required by the EU Animal Health Law, it is obvious that teaching of the necessary competences is embedded throughout the whole veterinary curricula. Biosecurity, overall health planning, prevention, diagnosis and treatment of diseases^{11 26} are part of the core competences that a veterinarian must acquire in order to be qualified to practise.^{24 25 33 34}

Day One Competences include also training on the use of all different veterinary medicinal products, that is, selection of the right medicine for species and indication, dosage, duration of treatment, administration, identification of adverse side effects, withdrawal periods, and so on. In the EU, any prescription for a veterinary medicinal product must be issued by a professional person, qualified to do so, in accordance with applicable national law.³⁵ In the EU, 27 of the 28 Member States (all except UK) allow only veterinarians to prescribe. However, in all 28 Member States, veterinarians are the only professionals entitled to prescribe antibiotics, controlled drugs (eg, sedatives) and other medicines with potential risk to animals and public health.³⁶

Zoonotic diseases are an important part of core competences that every veterinarian must acquire in order to be able to recognise, report or take appropriate actions. Zoonotic pathogens of aquatic origin, such as bacteria, parasites, viruses or fungus, can be transmitted to humans either via contact with the aquatic animals, their products, the water they are kept in or through the consumption of raw or undercooked fish products.^{37 38} Training veterinarians to recognise zoonotic diseases both on live animals or carcasses is a core Day One Competence in European veterinary curricula.^{24 25 33} Therefore, veterinarians play a crucial role in ensuring public health through diagnosing and reporting zoonotic diseases or thorough proper food inspection of fish products intended for food consumption.

Fish welfare is another field where veterinarians can make an important contribution to its development. Animal welfare has an overall impact on animal diseases as well as production and food safety. Like with all other animals, the presence of veterinarians in the fast expanding aquaculture industry is crucial to make sure that farmed individuals are treated with care and ensure coverage of their needs according to the species.^{11 39}

Finally it should be acknowledged that the concept of One Health, recognising that humans, animals and the environment are interconnected,^{40 41} is gaining more and more value in our society. The One Health approach in

aquatic medical practice can help us, for example, to identify links of transmission of pathogens between terrestrial and aquatic species or to better understand the impact of the use of medicines, including antibiotics, in the environment, for example, streams and groundwater.⁴²

Despite all the exposed evidence on the principles applying in both the aquatic animal and in the terrestrial animal farming in a similar way, such as prevention, biosecurity, animal health plans, antimicrobial resistance, responsible use of medicines, animal welfare, One Health, and so on, the results of our survey show a great diversity in the time allocated for teaching of aquatic animal health within the different curricula in the EU and EFTA (tables 1 and 2).

Moreover, we verified that, in many VEEs the training of competences in aquatic animal health is embedded in many subjects of the core veterinary curricula together with the ones applying for terrestrial animal health.

Quality assurance of veterinary education in Europe

A study on transposition of the Directive on the recognition of professional qualifications conducted on behalf of the Commission in 2009 clearly indicated, '*the Member States lack trust in each other's educational systems and it is important to establish this trust if the Directive is to work properly.*'⁴³

Additionally, no way of enforcement has been in place to ensure the compliance of the VEEs with the requirements set in the above piece of legislation on professional qualifications. EAEVE and FVE have identified that gap long ago. In order to address any discrepancies, the veterinary profession has taken responsibility and established the ESEVT,¹⁶ a professional peer evaluation system for VEEs leading to their 'Accreditation'. ESEVT is the only Europe-wide, profession-specific evaluation system that ensures efficient preparation of the veterinary students for the labour market. It has been running successfully for more than 33 years,⁴⁴ and evaluates the teaching and learning in higher education according to the approved standard operating procedure (SOP).⁴⁵ EAEVE, which is the accrediting body implementing ESEVT, has been recently become a full member of the European Association for Quality Assurance in Higher Education.⁴⁶

It is worth mentioning that assessment of students is one of the major requirements of ESEVT, which must be clearly demonstrated, in order for a VEE to gain the status of 'Approval' or 'Accreditation'. This is an important note considering that often assessment drives learning of students. Therefore, lack of a valid and reliable system in place for the assessment of clinical skills and Day One Competences of its students in a VEE constitutes a major deficiency that may lead to non-approval of the given VEE.

Our survey showed that 32 out of the 68 'Approved/Accredited schools' offer training on aquatic animal veterinary medicine as a separate subject and 34 of them as part of other subjects. In two of the 'Approved/Accredited VEEs', despite the inclusion of public health teaching

on inspection of food stuff in their core curriculum, they declared that they do not include any teaching in aquatic animal health, maybe as a consequence of misunderstanding, or disambiguation of terminology used in course descriptions. Nevertheless, one of these two VEEs commented that they are working towards that direction in line with a recommendation made by the ESEVT following their evaluation. The other VEE with a negative reply commented that while they do not have a subject foreseen in their undergraduate curriculum, they however organise a national veterinary specialisation postgraduate programme, giving that way the opportunity to interested veterinarians to get a better insight in the sector and its needs.

ESEVT provides assurance to the public that they can trust the quality of graduating veterinarians and the services they deliver by promoting harmonisation of veterinary training in the EU and beyond. ESEVT should assess and promote the teaching of aspects related to aquatic animal health, aquaculture and inspection of fish products intended for human consumption.

Veterinarians and other aquatic animal health professionals

Some European universities, established especially in countries with a significant production of aquaculture, such as Technological Educational Institute of Messolonghi in Greece,⁴⁷ Las Palmas University in Spain,⁴⁸ University of Stirling in UK,⁴⁹ and others, have developed programmes on aquatic animal farming. Those are mainly four-year programmes (European Qualifications Framework (EQF),⁵⁰ level 6) focused on aquatic animal farm management and sustainable production. Their objectives and competence level are different from the ones required for undergraduate veterinarians.^{24–26}

Veterinary education, on the other hand, is regulated in the EU. Directive 2005/36/EC,²⁴ as amended by Directive 2013/55/EU,²⁵ lays down the minimum requirements for veterinary surgeons, that is, a minimum duration of five years, a listing of the competences to acquire (Article 38) and the subjects to train undergraduates (Annex V). All VEEs of the EU and EFTA have a five or six-year curriculum, which is equivalent to level 7 of the EQF.⁵⁰

What is important to consider is that veterinarians are trained and empowered by legislation to evaluate the health of animals, including aquatic animals, to diagnose, to prescribe medicines, to notify for diseases and to ensure safe food for the consumers. Due to the major importance for public health, the veterinary profession is a regulated profession. This means that each veterinarian is registered to, licensed by and accountable to the national competent authority/statutory body of the country where they provide services. Each veterinarian has to follow the professional Code of Conduct,⁵¹ and failure to do so may lead to sanctions. Fish (or other aquatic animals) are not specifically mentioned in the current Veterinary Act,⁵¹ and this has been interpreted that the Act does not apply to fish, therefore anyone may diagnose and treat fish diseases.¹¹ However, Article 12 of

the Animal Health Law clearly lays down the necessary competences that the professional dealing with aquatic animals should have. Further to this, other pieces of legislation of the EU apply as well, such as the EU legislation about veterinary medicines.²⁶ The currently applying law lays down that veterinary prescription is ‘*any prescription for a veterinary medicinal product issued by a professional person qualified to do so in accordance with applicable national law.*’³⁵ However it should be highlighted that for 27 of the 28 Member States of the EU only veterinarians are allowed to prescribe. In all 28 Member States only veterinarians can prescribe antibiotics, controlled drugs (eg, sedatives) and other medicines with potential risk to animal and public health.³⁶ While antimicrobials, anaesthetics, vaccines, and others are medicines that need a prescription by a veterinarian, it has at the same time to be acknowledged that aquaculture suffers from a remarkable lack of appropriate veterinary medicines authorised for aquatic species and all indications in most Member States.⁵² In the case of a diagnosed disease for which no available authorised product exists, the veterinarian is the only professional empowered to select and prescribe the appropriate medicine under the cascade system.^{11 53}

The FVE survey of the veterinary profession in Europe⁵⁴ shows that in most European countries, even the ones with a strong aquaculture sector, the proportion of the veterinarians occupied in this field is less than 1 per cent (≤ 1 per cent). Only Norway has a significant number of veterinarians (10 per cent) focusing in aquaculture. Therefore, in some Member States for historical reasons, or due to the lack of veterinarians dealing with aquatic animal diseases, a specialised profession exists called ‘aquatic animal health professionals’.^{26 39} However, we have to remark that those professionals are not veterinarians, they have not received the overall training of a veterinarian, do not have the same responsibilities, for example, with regard to application of certain medicinal products, and most probably have to be under the supervision of a veterinarian. Paraprofessionals should only be able to do specific tasks and always work under the supervision of a licensed veterinarian. Additionally, in countries where aquatic animal health professionals or other paraprofessionals exist, they should be sufficiently trained and regulated under the existing National Veterinary Licensing Framework to ensure that they are accountable for acts linked to their competences.

A sustainable European aquaculture production in the future should encompass that aquatic animal health professionals and veterinarians should collaborate closely. Each professional should undertake responsibilities according to their training, competences and law requirements.

Continuous professional development in aquatic animal veterinary medicine

It should be acknowledged that all recognised VEEs require graduates to gain a basic understanding of the anatomy, physiology and other biological functions of all

animal types, including aquatic species.^{24 25 31} European Directives oblige to train a general curriculum for veterinary undergraduates, so the training is developed in a way that allows all veterinary students to gain the Day One Competences in the many different disciplines of veterinary medicine and to prepare for different career paths. More skills are then obtained through postgraduate training as well as through on-the-job clinical experience contributing to continuous professional development. As it happens with any discipline of the veterinary medicine, any veterinarian willing to take more complex roles in aquatic animal business should complement his/her knowledge and enhance his/her competence.³¹

Continuous professional development is a professional responsibility for veterinarians in the EU,⁵¹ Recital 15 of Directive 2013/55/EC,²⁵ encourages and promotes lifelong learning for all regulated professions in the EU. Veterinarians are responsible for being updated on latest developments in veterinary science, developing their Day One qualifications, advancing professionally and preparing for more complex tasks and roles. Veterinary profession in Europe strongly promotes the principle of continuous education.⁵⁵ Veterinarians shall maintain and enhance their knowledge and skills relating to the state of veterinary science.

Results of our survey show that 43.5 per cent (30 out of 69) of the VEEs that provided data on postgraduate training organise such programmes. The level of postgraduate education varies from short courses, Master or PhD programmes to specialisation programmes.

In some Member States of the EU and EFTA, the highest qualification leading to specialist-level recognition can be achieved by undertaking a National Diploma in aquatic animal medicine and production. This is the case, for example, in Italy, Norway, Spain and the UK. Additionally, the European Board of Veterinary Specialization,⁵⁶ provisionally accepted in April 2014, an ECAAH, established with a view to provide European-wide recognition to veterinary specialists in aquatic animal health.²⁰

Further to this, it is worth mentioning that the World Aquatic Veterinary Medical Association is implementing a Certified Aquatic Veterinarian programme,⁵⁷ to certify veterinary practitioners who are not specialists, in having core skills, knowledge and experience in the field practice in aquatic animal medicine with a wide variety of aquatic species.

The veterinary profession in Europe has recently established the accrediting body named Veterinary Continuous Education in Europe (VETCEE).⁵⁸ VETCEE was established with a view to encourage harmonisation and quality of postgraduate training programmes for veterinarians in order to facilitate recognition of their competences throughout the EU. This initiative is in line with the recommendations of the Directives,^{24 25} and the OIE,⁵⁹ about lifelong learning for the veterinary profession, as well as the need of veterinarians working in the field for quality career development. VETCEE runs an accreditation process for structured continuous

professional development (CPD) for practising veterinarians in different fields at a level between the graduate veterinarian and the diplomate. Unfortunately, VETCEE does not yet propose a Dossier of Competences in aquatic animal health. Nevertheless, this is an area where VETCEE may have to explore potentials to satisfy the needs of the veterinary profession in Europe that is working in this field.

CONCLUSIONS

Aquaculture and fisheries, and also ornamental fish trade, are very dynamic sectors in EU, where veterinarians have a fundamental role to play by ensuring health and welfare of aquatic species, productivity and profitability of fish farming, public health and ecosystem conservation.

The results of our survey show that the great majority, 96 per cent (74 out of 77) of the VEEs in the EU and EFTA, have teaching of aquatic animal veterinary medicine incorporated to a different extent in their curricula. While VEEs integrating adequately aquatic animal medicine in their curriculum exist and are evenly distributed in all regions of Europe, it is important to ensure that Day One Competences in aquatic animal health and aquaculture are part of the core veterinary curricula of all European VEEs. ESEVT assures that the veterinary curricula efficiently prepare veterinarians and develop their core competences. ESEVT should assess and promote the teaching of aspects related to aquatic animal physiology and health, treatment of aquatic animals, aquaculture production and inspection of fish products intended for human consumption. That would enable graduate veterinarians to acquire the necessary competences required for entry roles in food inspection or aquaculture industry and motivate them to start a career in this sector.

With outlooks on growth and development of European aquaculture forecasting a doubling of production in the next 10–15 years and an increased focus on the health and welfare of aquatic species, it is evident that future veterinarians should be encouraged and prepared to start a career in this sector. A sustainable European aquaculture production in the future will increase the demand for more veterinarians. The veterinary profession should be prepared for this challenge and advocate for an EU framework that encompass veterinarians and aquatic animal professionals collaborating closely and undertaking responsibilities according to their training, competences and law requirements.

Acknowledgements Special thanks to all the veterinary education establishments—EAEVE members who contributed data to this survey and to the members of the European Coordinating Committee on Veterinary Training (ECCVT) who also supported this whole project. Special thanks also to Professor László Fodor, former president of the EAEVE, who proposed and supported this project. The authors Ana Bravo and Jimmy Saunders contributed equally to this work.

Funding The authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors.

Provenance and peer review Not commissioned; externally peer reviewed.



Data sharing statement No additional data are available.

Open access This is an open access article distributed in accordance with the Creative Commons Attribution Non Commercial (CC BY-NC 4.0) license, which permits others to distribute, remix, adapt, build upon this work non-commercially, and license their derivative works on different terms, provided the original work is properly cited and the use is non-commercial. See: <http://creativecommons.org/licenses/by-nc/4.0/>

REFERENCES

1. Livengood EJ, Chapman FA. The Ornamental Fish Trade: An Introduction with Perspectives for Responsible Aquarium Fish Ownership edis. (accessed 30 Jul 2018).
2. EUROSTAT. Report on fisheries statistics. 2016 http://ec.europa.eu/eurostat/statistics-explained/index.php?title=Fishery_statistics_in_detail&oldid=311673 (accessed 30 Jul 2018).
3. STATISTA. Number of ornamental fish in the European Union 2016 by country. 2016 www.statista.com/statistics/515432/ornamental-fish-population-european-union-eu-by-country/ (accessed 30 Jul 2018).
4. Dey VK. The Global Trade in Ornamental Fish. *INFOFISH International* 4/2016. 2016:52–5.
5. EUROSTAT. Report on aquaculture statistics. 2017 http://ec.europa.eu/eurostat/statistics-explained/index.php/Aquaculture_statistics (accessed July 30, 2018).
6. EFTA. European Free Trade Association. 2018 www.efta.int (accessed July 30, 2018).
7. FAO. Yearbook. Fishery and Aquaculture Statistics, 2016. <http://www.fao.org/3/i9942t/i9942t.pdf>. (accessed 30 Sep 2018).
8. European Parliament. The long-term economic and ecologic impact of larger sustainable aquaculture. 2014 [http://www.europarl.europa.eu/RegData/etudes/STUD/2014/529084/IPOL_STU\(2014\)529084_EN.pdf](http://www.europarl.europa.eu/RegData/etudes/STUD/2014/529084/IPOL_STU(2014)529084_EN.pdf) (accessed 30 Jul 2018).
9. European Commission. Food From the Oceans. 2017 https://ec.europa.eu/research/sam/pdf/sam_food-from-oceans_report.pdf#view=fit&pagemode=none (accessed 30 Jul 2018).
10. Varadi L, Szucs I, Pekar F. *et al* Aquaculture development trends in Europe. In: Subasinghe RP, Bueno P, Phillips MJ, Hough C, McGladdery SE, Arthur JR, . eds. *Aquaculture in the Third Millennium. Technical Proceedings of the Conference on Aquaculture in the Third Millennium*. Bangkok, Thailand: NACA, 2000:397.
11. Soutar R. Vets and aquaculture: an evolving relationship *Veterinary Record*. 2015;177:252–5 <http://veterinaryrecord.bmj.com/content/177/10/252>.
12. Ohr R. Pet Study: 'Pet Ownership as Economic Factor' - The economic significance of pet ownership in Germany. 2014 <https://www.uni-goettingen.de/en/pet+study%3a+pet+ownership+as+economic+factor+in+germany/500479.html> (accessed 30 Jul 2018).
13. EUR-Lex: Official Controls Regulation (EU) 2017/625. 2018 <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32017R0625&from=EN> (accessed 30 Jul 2018).
14. EAEVE. European Association of Establishments of Veterinary Education. 2018 <http://www.eaeve.org> (accessed 30 Jul 2018).
15. EAEVE. Self-Evaluation Report and Visitation Report of visited Establishments. 2018 <http://www.eaeve.org/esevt/ser-and-visitation-report-of-visited-establishments.html> (accessed 30 Jul 2018).
16. EAEVE. European System of Evaluation of Veterinary Training (ESEVT). 2018 <http://www.eaeve.org/esevt/sop.html> (accessed 30 Jul 2018).
17. FVE. Federation of Veterinarians of Europe. 2018 <http://www.fve.org/> (accessed 30 Jul 2018).
18. Spector MJ, Merrill DM. Handbook of Research on Educational Communication. 2014 <http://members.aect.org/edtech/ed1/41/41-01.html> (accessed 30 Jul 2018).
19. EAEVE. The Establishments' Status after the ECOVE meeting held on 17 May 2017. 2017 https://www.eaeve.org/fileadmin/downloads/establishments_status/EAEVE_Establishments_Status_November_2017_approved_by_ExCom_on_29.01.2018.pdf (accessed 30 Jul 2018).
20. European College of Aquatic Animal Health. ECAAH. 2018 <https://ebvs.eu/colleges/ECAAH> (accessed 30 Jul 2018).
21. EUR-Lex. Glossary of summaries: Subsidiarity. 2018 <http://eur-lex.europa.eu/summary/glossary/subsidiarity.html> (accessed 30 Jul 2018).
22. European Committee of Regions. Subsidiarity monitoring in the area of education, vocational training and youth. 2018 <https://portal.cor.europa.eu/subsidiarity/policyareas/Pages/Education.aspx> (accessed 30 Jul 2018).
23. EU Publications. Treaty of Lisbon. 2018 <https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:C:2007:306:TOC> (accessed 30 Jul 2018).
24. EUR-Lex. Directive 2005/36/EC of the European Parliament and of the Council of 7 September 2005 on the recognition of professional qualifications. 2018 <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32005L0036&from=EN> (accessed 30 Jul 2018).
25. EUR-Lex. Directive 2013/55/EU of the European Parliament and of the Council of 20 November 2013 amending Directive 2005/36/EC on the recognition of professional qualifications and Regulation (EU) No 1024/2012 on administrative cooperation through the Internal Market Information System ('the IMI Regulation'). 2018 <http://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:32013L0055&from=EN> (accessed 30 Jul 2018).
26. EUR-Lex. Regulation (EU) 2016/429 of the European Parliament and of the Council of 9 March 2016 on transmissible animal diseases and amending and repealing certain acts in the area of animal health ('Animal Health Law'). 2018 <http://eur-lex.europa.eu/legal-content/EN/TXT/?uri=OJ:L:2016:084:TOC> (accessed 30 Jul 2018).
27. FAO. FAO Support to the WTO Negotiations at the 11th Ministerial Conference in Buenos Aires. 2017 <http://www.fao.org/3/a-i8003e.pdf> (accessed 30 Jul 2018).
28. Greenville J. Chapter 1- Issues in Agricultural Trade Policy: an overview. Proceedings of the 2014 OECD Global Forum on Agriculture. 2015 <http://www.oecd.org/agriculture/issues-in-agricultural-trade-policy-9789264233911-en.htm> (accessed 30 Jul 2018).
29. OIE. Aquatic Animal Health Code. 2017 <http://www.oie.int/en/international-standard-setting/aquatic-code/access-online/> (accessed 30 Jul 2018).
30. WTO. The WTO Agreement on the Application of Sanitary and Phytosanitary Measures (SPS Agreement). 2001 https://www.wto.org/English/tratop_e/sps_e/spsagr_e.htm (accessed 30 Jul 2018).
31. DeHaven WR, Scarfe AD. (2011) Professional education and aquatic animal health: a focus on aquatic veterinarians and veterinary para-professionals. Proceedings of the OIE Global Conference on Aquatic Animal Health: Aquatic Animal Health Programmes: their benefits for global food security. Reading, June 28 to 30. 2011:139.
32. Iatridou D, Nagy Z, De Briyne N, *et al*. Mapping the Teaching of Laboratory Animal Science and Medicine in the European Union and European Free Trade Area. *J Vet Med Educ* 2018:1–11.
33. ECCVT. Statement on Day One Competences & Annex V of Directive 2013/55. 2018 http://fve.org/education/docs_to_download/ECCVT%20Newsletter/Other%20activities/2015_2%20D1C_Adopted.pdf (accessed 30 Jul 2018).
34. World Organization for Animal Health (OIE). Guidelines on Veterinary Education Core Curriculum. 2013 <http://www.oie.int/en/solidarity/veterinary-education/veterinary-education-core-curriculum/> (accessed 30 Jul 2018).
35. EUR-Lex. Directive 2001/82/EC of the European Parliament and of the Council on the Community code relating to veterinary medicinal products. 2018 <https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1528891778375&uri=CELEX:32001L0082> (accessed 30 Jul 2018).
36. FVE. The Federation of Veterinarians of Europe insists on a reliable quality assurance for the veterinary prescription. 2015 http://fve.org/uploads/publications/docs/039_veterinary_prescription_final.pdf (accessed 30 Jul 2018).
37. Lowry T, Smith SA. Aquatic zoonoses associated with food, bait, ornamental, and tropical fish. *J Am Vet Med Assoc* 2007;231:876–80.
38. Haenen OL, Evans JJ, Berthe F. Bacterial infections from aquatic species: potential for and prevention of contact zoonoses. *Rev Sci Tech* 2013;32:497–507.
39. FVE. Veterinary aspects of aquatic animal health and welfare, aquaculture and ornamental fish trade, Report of FVE working group on Aquatic Animal Health and Aquaculture. 2014 http://fve.org/uploads/publications/docs/veterinary_aspects_of_aquatic_animal_health_and_welfare_adopted.pdf (accessed 30 Jul 2018).
40. World Health Organisation. One health. 2018 <http://www.who.int/features/qa/one-health/en/> (accessed 30 Jul 2018).
41. World Organisation for Animal Health. One Health. 2018 <http://www.oie.int/en/for-the-media/onehealth/> (accessed 30 Jul 2018).
42. Weber ES, Blanc G, Hedrick RP. Essential veterinary education in fish health and disease: a global perspective. *Rev Sci Tech* 2009;28:551–8.
43. European Parliament. Study on Transposition of the Directive on the recognition of professional qualifications. 2009 http://www.ordemengenhieiros.pt/fotos/editor2/eng.civil/recognitionofprofessionalqualification_ep.pdf (accessed 30 Jul 2018).

44. ECCVT. Harmonisation of veterinary education: fundamental for establishing EU citizens' trust in veterinary services. 2015 http://fve.org/education/docs_to_download/2015_1%20Position%20on%20ESEVT%20FINAL.pdf (accessed 30 Jul 2018).
45. EAEVE. ESEVT Standard Operating Procedure (SOP) as approved at the Uppsala EAEVE General Assembly on 12 May 2016. 2016 http://www.eaeve.org/fileadmin/downloads/SOP/ESEVT_Uppsala_SOP_May_2016.pdf (accessed 30 Jul 2018).
46. European Association for Quality Assurance in Higher Education. <https://enqa.eu/> (accessed 30 Sep 2018).
47. Department of Fisheries. Aquaculture Technology, T.E.I. of Western Greece. 2018 <http://www.tay.teiwest.gr/en/> (accessed 30 Jul 2018).
48. Degree in Marine Science, University of Las Palmas de Gran Canaria. 2018 http://www2.ulpgc.es/index.php?pagina=plan_estudio&ver=wpe002&codTitulacion=4006&tipotitulacion=G (accessed 30 Jul 2018).
49. Bsc on Aquaculture, University of Stirling. 2018 <https://www.stir.ac.uk/undergraduate-study/course-information/courses-a-to-z/school-of-natural-sciences/aquaculture/> (accessed 30 Jul 2018).
50. European Commission. Descriptors defining levels in the European Qualifications Framework (EQF). 2018 <https://ec.europa.eu/ploteus/content/descriptors-page> (accessed 30 Jul 2018).
51. FVE. Code of Conduct. 2012 http://fve.org/uploads/publications/docs/bro_fve_code_of_conduct_2012.pdf (accessed 30 Jul 2018).
52. FVE. FishMedPlus: Coalition aiming at increasing the greater availability of authorized veterinary medicinal products for aquaculture on the market of European Union and EFTA countries. 2016 http://www.fve.org/uploads/publications/docs/final_press_release_fishmedplus.pdf (accessed 30 Jul 2018).
53. FVE. Cascade Guide for veterinarians if no authorised medicinal product is available, FVE publication. 2014 http://www.fve.org/veterinary/pdf/medicines/cascade/FVE_bro_cascade_jan2014.pdf (accessed 30 Jul 2018).
54. FVE Survey of the veterinary profession in Europe. http://www.fve.org/news/download/FVE%20Survey_full_final.pdf (accessed 22 Sep 2018).
55. FVE. position on Continuous Professional Development. 2018 http://fve.org/uploads/publications/docs/012_fve_position_on_cpd_ga_adopted_june_2018.pdf (accessed 30 Jul 2018).
56. European Board of Veterinary Specialisation:EBVS. 2018 <http://ebvs.eu> (accessed 30 Jul 2018).
57. World Aquatic Veterinary Medical Association. WAVMA:Certified Aquatic Veterinary Practitioner (Cert-AqVP). 2018 <https://www.wavma.org/CertAqV-pgm> (accessed 30 Jul 2018).
58. Veterinary Continuous Education in Europe (VETCEE). <http://www.fve.org/education/vetcee.php> (accessed 30 Jul 2018).
59. World Organization for Animal Health (OIE). Recommendations of the 4th OIE Global Conference on Veterinary Education. http://www.oie.int/eng/vet-education-conf2016/recommendations/A_Final_recommendations_Thailand_education.pdf (accessed 30 Jul 2018).