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Teaching science in laboratory animals and imaging diagnosis in ludovicense veterinary medicine

ARTICLE

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Abstract
Veterinary medical education is governed by national curricular guidelines (Brazil, 2019), through which universities establish their pedagogical course projects (PPC). This research involved an active search for documents (PPC and syllabi) with the aim of visualizing the teaching offering of Science in Laboratory Animals (CAL) and Diagnostic Imaging (DI) in the Veterinary Medicine course at the State University of Maranhão, prioritizing the Political Pedagogical Projects in the period 1995 and 2021. The data obtained showed implementation, changes in syllabi, nomenclature and workload of the DI discipline. On the other hand, the CAL subject was never offered as an elective or mandatory course during the period studied. It was concluded that the DI discipline was offered with a reduced workload, challenging teachers to change teaching methodologies. On the other hand, the course does not prepare Veterinarians to work in the CAL area nor does it sensitize them to issues pertinent to the area.
Keywords: Science in Laboratory Animals. Imaging Diagnosis. Teaching. Veterinary Medical Education. Professional Training.

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Resumo
O ensino médico veterinário é regido pelas diretrizes curriculares nacionais (Brasil, 2019), através destas, as universidades estabelecem seus projetos pedagógicos de curso (PPC). Esta pesquisa envolveu busca ativa de documentos (PPC e ementas) com intuito de visualizar a oferta de ensino de Ciência em Animais de Laboratório (CAL) e Diagnóstico por Imagem (DI) no curso de Medicina Veterinária da Universidade Estadual do Maranhão, priorizando os Projetos Político Pedagógicos no período de 1995 e 2021. Os dados obtidos evidenciaram implantação, mudanças em ementas, nomenclatura e carga horária da disciplina DI. Em contrapartida, a disciplina de CAL nunca foi oferecida como eletiva ou

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obrigatória no período pesquisado. Concluiu-se que a disciplina DI foi ofertada com carga horária reduzida, desafiando os docentes a mudanças nas metodologias de ensino, em compensação, o curso não prepara o Médico Veterinário para atuar na área de CAL e nem o sensibiliza com assuntos pertinentes à área.
Palavras-chave: Ciência em Animais de Laboratório. Diagnóstico por Imagem. Docência. Ensino Médico Veterinário. Formação Profissional.

1 Introduction

This article is the result of a doctoral research in which documentary research was conducted, actively seeking the Pedagogical Projects of the Course (PPC) from the Veterinary Medicine course at the State University of Maranhão (UEMA). These PPCs cover the period from 2015 to 2023.

According to Law No. 9.394, from November 20, 1996, universities are multidisciplinary institutions responsible for training higher-level professional staff, research, extension, and the domain and cultivation of human knowledge. According to Article No. 207 of the Brazilian Constitution of 1988 (Brasil, 1988): "Universities enjoy didactic-scientific, administrative, and financial and patrimonial management autonomy, and will adhere to the principle of the inseparability between teaching, research, and extension."

Therefore, the tripod formed by teaching, research, and extension constitutes the fundamental axis of Brazilian universities and cannot be compartmentalized. Equalized, these basic functions deserve equal treatment by higher education institutions, which, otherwise, will violate the legal precept (Andrade; Moita, 2009).

The four pillars of education (learning to know, learning to do, learning to be, and learning to live together), discussed in the report to UNESCO by the International Commission on Education for the 21st Century, *Education: A Treasure to Discover* (Lyotard, 1986, p. 36), help us understand the importance of the interaction and existence of these pillars in the teaching-learning process.

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Technical and scientific training is no longer sufficient for an individual's integration into the society in which they live. Therefore, education, to maintain its mission, needs to adopt methodologies that incorporate the four fundamental pillars of education/learning mentioned earlier.

Thus, there is a search for reflection on teaching practice. Education is linked to institutions in its practice. It is important to understand that modern society is transforming and changing educational concepts and understandings.

Therefore, one of the basic assumptions of education should be the preparation of the person, which includes both spirit and body in their entirety. The essence of "learning to be" advocates for the holistic preparation of the human being, so they have the capacity and autonomy to develop critical thinking, specifically in this research context, to relate subjects related to diagnostic imaging and/or science in laboratory animals to professional practice as an alumni of the university researched.

The four pillars were developed with a focus on basic education; however, their concepts can be applied in higher education (Pessoa; Macedo, 2018). This is understood from Mello's (2011) study, which argues that universities must advance beyond technical preparation focused on content, towards a broader capacity for knowledge that involves critical reasoning and worldview.

To obtain the title of veterinarian, the student must undergo technical training with a workload that varies between institutions and according to the pedagogical project of each course. At the State University of Maranhão (UEMA), which is the focus of this study, veterinarians were trained with a total workload of up to 5,115 hours. Currently, training is completed with 4,395 hours, in accordance with the National Curriculum Guidelines (Brasil, 2019). These guidelines establish that the curriculum must cover essential content in three main areas: Biological and Health Sciences, Humanities and Social Sciences, and Veterinary Medicine Sciences.

Technical preparation has been increasingly shorter in terms of workload, but what is expected is the formation of a critical professional, with developed skills and

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competencies for making good decisions in all moments of their professional life, whether in teaching or in medical and research specialties.

Considering that Veterinary Medicine is an undergraduate course with technical training, educational aspects should not be analyzed in a fragmented manner. The graduate who chooses the area of clinical medicine can follow either into teaching or into clinical practice. In both ways, it is essential that this professional possesses solid knowledge in various areas. According to the National Curriculum Guidelines (DCNs) for the undergraduate Veterinary Medicine course (Brasil, 2019), it is essential to develop fundamental skills and competencies. These competencies will be crucial throughout their career, directly influencing their actions in clinical cases, in conducting research with laboratory animals, and in performing teaching in the classroom.

Among the competencies outlined in the DCNs (Brasil, 2019), we highlight two that are of utmost importance for the practice of clinical medicine: “develop, guide, perform, and interpret clinical and laboratory exams, as well as identify and interpret clinical signs and morphofunctional changes” and “establish diagnosis, prognosis, treatment, and prophylactic measures, both individual and population based.” That is, in the act of medical intervention during and after consultation, it is necessary to choose appropriate exams for the situation, whether it is preventive routine care or urgent/emergency cases.

The practice of small animal clinical medicine (companion animals) has undergone constant refinement. Not too long ago, the general practitioner would solve or attempt to resolve all the demands that came their way. Traditionally considered paramount for diagnoses, clinical medicine needs to be well-executed, and for this, its four pillars — inspection, palpation, auscultation, and percussion — must be harmoniously aligned. When this alignment exists, the diagnosis can be made there, and the patient can be referred to surgical clinics or even for complementary exams that clarify parameters and ways to make the post-clinical diagnosis approach more accurate.

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Within clinical medicine, imaging exams may be necessary to elucidate cases and surgical delimitations, that is, as diagnostic tools and/or facilitators when making medical decisions.

The skills and competencies for prescribing and interpreting imaging exams are developed in curricular components such as Diagnostic Imaging, Imaging Techniques, and Radiology, among others. Traditionally, the syllabi of these components include, on one hand, the widely known radiology technique, and on the other hand, computed tomography, which is still not as explored during undergraduate education.

The ability of tomography to provide highly detailed images, without image overlaps and based on the density of structures, allows for the evaluation of many bone and soft tissues (especially when associated with contrast agents), benefiting almost all specialties in veterinary medicine — particularly oncology, neurology, and orthopedics. Both neurology and orthopedics benefit from a common point provided by the modality, which is the evaluation of the spine, especially in acute cases of paralysis. Tomography is a more widely available exam, faster than magnetic resonance imaging, and can diagnose the cause in most cases, except for inflammatory conditions that will be visible in MRIs.

The use of computed tomography (CT) for early diagnoses of pulmonary metastasis caused by mastocytomas can greatly improve the prognosis of treatment through CT imaging. Mastocytomas can present a homogeneous or heterogeneous appearance (Lorigados *et al.*, 2012).

As they represent skin tumors, mastocytomas can be palpated and assessed for their consistency and adherence to deeper planes, in addition to being clinically measured. However, the evaluation through tomography proves to be more accurate, especially if these formations extend to deeper planes. It is stated that a tumor has a cleavage line with adjacent tissues when a space, usually of fatty attenuation, is observed between them.

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This is a very important aspect in outlining surgical margins whenever the surgical procedure is considered as a treatment. The surgical margin has been considered one of the criteria for establishing the prognosis for mastocytomas (Seguin *et al*., 2001; Thamm; Vail, 2007; Dobson *et al*., 2002; Michels *et al*., 2002; Simpson *et al*., 2004). Regarding fat, its obliteration should be observed in some cases and considered suspicious, as it may represent inflammation, neovascularization, or even a neoplastic infiltrate into the adipose panniculus (Webb, 2000).

According to Lorigados *et al*. (2012), computed tomography (CT) has proven to be highly effective in defining tumors, directly contributing to the precise planning of surgical margins. Therefore, there is scientific support that demonstrates the importance of CT in safer and more effective medical interventions. Its lack of use, due to lack of knowledge, may compromise the diagnosis and treatment, putting the patient's life at risk.

In addition to diagnostic imaging, veterinarians currently rely on the regulatory resolution RN 49/2021 from the National Council for Animal Experimentation Control (CONCEA). This resolution states that the individual holding a Veterinary Medicine degree is entitled to work in the production, maintenance, and experimentation of laboratory animals. However, according to Dias *et al*. (2024), the State University of Maranhão (UEMA) did not train veterinarians with the skills and competencies for this, nor did it raise awareness about this topic.

This research involved actively searching for documents (Pedagogical Project of the Course and syllabi) from the Veterinary Medicine course at the State University of Maranhão (UEMA) to observe the implementation, development, and offering of the subjects of Diagnostic Imaging and Laboratory Animal Science through the PPCs and syllabi developed between 2015 and 2023.

2 Methodology

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The comparative exploratory-descriptive study, based on Dias (in preparation) (2017) and Dias *et al*. (2024), was conducted at the Veterinary Medicine course of the State University of Maranhão (UEMA), and analyzed the following curricular components: Diagnostic Imaging and Laboratory Animal Science between the years of 2015 and 2023.

The data regarding the curricular components were obtained through research in physical documents, digitized documents, and fully virtual documents. The virtual and digitized documents were found on the website of the Undergraduate Pro-Rector's Office (PROG), available online, including the Pedagogical Project of the Course (PPCs) from 2015 and 2023. Based on the collection of these documentary data, the methodological framework of Dias *et al*. (2024) was used to support the analysis of the curricular structures of the Veterinary Medicine courses, with an emphasis on the components Diagnostic Imaging and Laboratory Animal Science.

2.1 Legal Aspects

This research began in the Master's program and continued in the Doctorate. Therefore, it is important to highlight the two moments of approval and the consequent opinions with different numbers.

The Research Ethics Committee (CEP) of the State University of Maranhão (UEMA) considered that: "The project is approved and ready to begin data collection and other related stages. All pending issues were addressed and corrected by the researcher and are in accordance with Resolution 466/12 of the National Health Council (CNS)." The project was approved under opinion number 3.941.480.

The doctoral “projetão” was submitted to Plataforma Brasil, directed to the Research Ethics Committee of UEMA (CEP-UEMA), where it received the identification number CAAE: 80620524.6.0000.5554. The project, titled *Ensino Médico-Veterinário: percepção sobre o ensino de diagnóstico por imagem entre*

discentes e egressos de São Luís do Maranhão, was approved under opinion number 6.975.040, resulting in several developments, including this article.

2.2. Inclusion and Exclusion Criteria

Due to the availability of physical and virtual files, the period adopted was from 2015 to 2023, excluding the Pedagogical Projects of the Course (PPCs) from 2008, 2001, and 1995, which were either not found or found partially damaged.

Thus, the inclusion criterion was the complete PPC found, with the syllabus of the researched subjects, and the exclusion criterion was the PPCs that were not located or damaged in a way that made their reading impossible at any point.

3 Results and Discussion

This research was developed through a documentary investigation, with the objective of analyzing the Pedagogical Projects of the Course (PPC) of Veterinary Medicine and establishing relationships between the syllabi of Diagnostic Imaging and Laboratory Animal Science, as presented in their different PPCs throughout the researched period.

Diagnostic Imaging is a mandatory curricular component in Veterinary Medicine courses. In the oldest course in the State of Maranhão, this component is located in the fifth semester. It was introduced in the 1995 curriculum under the name "Method and Technique of Support for Diagnosis I and II."

MTAD I covered topics related to Clinical Pathology, while MTAD II focused on imaging techniques, with an emphasis on Radiology, having a workload of 90 hours and 60 hours, respectively.

In the 2001 curriculum, these components were renamed, and MTAD II became known as Diagnostic Imaging, maintaining the workload of 60 hours established at its implementation.

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The mentioned data were obtained through the records of two graduates, one from 1998, when the 1995 PPC was still in force, and another from 2002, under the 2001 PPC. The PPCs were not located. Considering the General Data Protection Law (LGPD) 13.709/2018, and since the graduates were not included in the research authorization framework, the document was transcribed without an image attached.

To this day, the aforementioned component still has the same workload as in 1995 and, according to the syllabi, aims to develop skills and competencies in X-ray and Ultrasound. However, there are other imaging diagnostic techniques, such as magnetic resonance imaging, computed tomography, endoscopy, and echocardiogram, that are part of the clinical routine.

In Table 1, the Diagnostic Imaging (CR) component approved in the most recent Pedagogical Project of the Course (PPC) from 2023 is presented. A significantly different syllabus can be observed when compared to the one in force in the 2015 PPC, as shown in Table 2. However, at no point is there a basic or complementary reference to guide the studies of computed tomography.

Table 1 - Syllabus of Diagnostic Imaging, updated in 2023, in the Pedagogical Project of the Course (PPC)

Curricular Component	Workload	Year	Origin
Diagnostic Imaging	60h	2023	Pedagogical Project of the Course (PPC)

SYLLABUS: The course is taught in a theoretical-practical format, where the history, importance in Veterinary Medicine, and the basic principles of interpretation and examination techniques are presented, including radiology, ultrasonography, and tomography.

BASIC REFERENCE:

ALMEIDA, F. A., BELLO, P., SANTOS, V. M. **Guia prático de radiologia veterinária de cães e gatos**. 2. ed. São Paulo: Globos, 2015.

BURK, R. L.; FENNEY, D. A. **Small animal radiology and ultrasound:** a diagnostic atlas and text. 3. ed. Saint Louis: Saunders, 2003.

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CARVALHO, C. F. **Ultrassonografia em pequenos animais.** São Paulo: Roca, 2004.

FELICIANO, M. A. R.; CANOLA, J. C.; VICENTE, W. R. R. **Diagnóstico por imagem em cães e gatos.** São Paulo: Medvet, 2015.

HAGEN-ANSERT, S. L. **Tratado de ultrassonografia diagnóstica**. Rio de Janeiro: Guanabara Koogan, 2003.

KEALY, J. K.; MCALLISTER, H. **Radiologia e ultrassonografia do cão e do gato.** São Paulo: Manole, 2005.

LAVIN, L. **Radiography in veterinary technology.** 4. ed. Philadelphia: Saunders, 2006.

COMPLEMENTARY REFERENCE:

NYLAND, T. G.; MATTOON, J. S. **Ultrassom diagnóstico em pequenos animais.** 2. ed. São Paulo: Roca, 2004.

ROSS, M.; DYSON, S. **Diagnosis, and management of lameness in the horse.** Saint Louis: Saunders, 2003.

SCHEBITZ, H. & WILKENS, H. **Atlas de anatomia radiográficas do cão e do gato.** 5. ed. São Paulo: Manole, 2000.

THRALL, D. E. **Textbook of veterinary diagnostic radiology.** 47. ed. Philadelphia: Saunders, 2019.

Source: State University of Maranhão (UEMA) (2023)

In Table 2, a curricular component with the nomenclature of Diagnostic Imaging is observed. However, it presents only two imaging techniques: radiology and ultrasonography, with no mention of other techniques in the syllabus or in the basic and complementary references.

Table 2 - Syllabus of Diagnostic Imaging offered in 2015 in the Pedagogical Project of the Course (PPC)

Curricular Component	Workload	Year	Origin
Diagnostic Imaging	60h	2015	Pedagogical Project of the Course (PPC)

SYLLABUS: Basic principles of diagnostic imaging, radiodiagnosis: Radiographic techniques, facilities, and radiological projections. Radioisotopes and radioactivity and their use in clinical

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practice. Ultrasound: Nature, properties, and equipment. Clinical interpretation of radiographic and ultrasonographic images.

BASIC REFERENCE:

BURK, R. L.; FENNEY, D. A. **Small animal radiology and ultrasound:** a diagnostic atlas andtext. 3. ed. Saint Louis: Saunders, 2003.

CARVALHO, C. F. **Ultrassonografia em pequenos animais.** São Paulo: Roca, 2004.

HAGEN-ANSERT, S. L. **Tratado de ultrassonografia diagnóstica.** Rio de Janeiro: Guanabara Koogan, 2003.

KEALY, J. K.; MCALLISTER, H. **Radiologia e ultrassonografia do cão e do gato.** São Paulo: Manole, 2005.

LAVIN, L. **Radiography in veterinary technology.** 3. ed. Philadelphia: Saunders, 2003.

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THRALL, D. E. **Textbook of veterinary diagnostic radiology.** 4. ed. Philadelphia: Saunders, 2002.

Source: State University of Maranhão (UEMA) (2023)

Comparing Tables 1 and 2, it is clear that the proposed diagnostic imaging focuses on two techniques: X-ray and ultrasound. This inference is made through the basic and complementary references related to the syllabus, ignoring other imaging techniques such as computed tomography (CT), magnetic resonance imaging (MRI), endoscopy, and echocardiogram.

Considering the results of Lorigados *et al*. (2012) on the use of computed tomography (TC) in mastocytomas and surgical planning, it can be asserted that students exposed to the content proposed in the syllabi presented in Tables 1 and 2 do not acquire sufficient knowledge to fully develop the skills and competencies outlined in the National Curriculum Guidelines (DCNs) (Brasil, 2019). This compromises the training of the generalist veterinarian — a central proposal of the

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DCNs and reflected in the Course Pedagogical Project (PPC) — limiting the students' ability to act safely and effectively in diagnostic imaging and clinical interventions.

In the histories of the graduates and the analyzed PPCs, the subject Science in Laboratory Animals is neither mandatory nor elective. This confirms the results of the documentary research by Dias *et al*. (2024), who, when questioning 43 Veterinary Medicine students from the same university about the question: "Do you feel prepared to work in the field of animal facilities and research installations?", received a response from an average of 94.5% of students stating they did not feel prepared.

This result regarding the component Science in Laboratory Animals (CAL) highlights that the four pillars of education, proposed by Delors (1998), and the reflection by Mello (2011), were not effectively applied. The absence of this discipline in the curriculum reveals a significant formative gap, making the academy responsible for incomplete training in this field, which is almost universally absent at the undergraduate level in Veterinary Medicine. Thus, it can be asserted that these professionals do not meet the requirements of RN 49/2021 by CONCEA, which establishes the diploma as a requirement to prove skills and competencies.

Considering Article 5 of the National Curriculum Guidelines for the undergraduate Veterinary Medicine course (Brasil, 2019):

> Art. 5º The undergraduate Veterinary Medicine course aims to develop the profile of the graduate/professional as a Veterinarian, with a generalist, humanist, critical, and reflective education, capable of understanding and addressing the needs of individuals, social groups, and communities regarding activities inherent to the professional practice in their specific fields of action in animal health, public health, and environmental health; veterinary clinical practice; preventive veterinary medicine; inspection and technology of animal-derived products; animal husbandry, production, and reproduction. The graduate should have knowledge of social, cultural, and political facts; economics and administration; logical reasoning skills, observation, interpretation, and analysis of data and information, as well as essential knowledge in Veterinary Medicine to identify and solve problems aiming at economic, social, and environmental sustainability and animal welfare. (Brasil, 2019).

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The absence of the CAL curricular component in the structure of the University and the course studied compromises the ethical and effective performance of graduates in Animal Ethics and Use Committees (CEUAs), as well as limiting their professional areas of practice. This is because students will not have the exposure that would sensitize and inspire them to seek greater knowledge in this field. The temporary replacement of professionals in this area may not exist both qualitatively and quantitatively.

Veterinary diagnostic imaging can be performed using various techniques and should not be limited to radiography (X-ray) and ultrasonography (US), as indicated in the current syllabi. The basic and complementary references for the discipline should be updated with more specific terminology for Veterinary Radiology.

Moreover, it would be ideal for other techniques—such as magnetic resonance imaging (MRI), computed tomography (CT), and endoscopy—to be addressed in a distinct curricular component or supplemented in the training. The distribution of essential content to ensure the formation of a generalist veterinarian, as proposed by the National Curriculum Guidelines (DCNs), becomes unfeasible with the 60-hour workload, which has been maintained for over 20 years, limiting the approach to these more advanced techniques.

The development of skills and competencies through this curricular component aims to enable students and future professionals to prescribe imaging exams. Given the complexity of clinical cases, it is essential that the veterinarian knows which exam is most appropriate for each situation. While they may specialize in diagnostic imaging, mastering various advanced techniques, this does not exempt them from the responsibility, as a general practitioner, to have at least basic knowledge of these techniques. This understanding is crucial so that they can prescribe exams assertively in their daily practice, ensuring more accurate diagnoses and more effective treatment.

From the data, it is understood that students can seek knowledge beyond their undergraduate studies. However, for this to happen, they need to be sensitized and motivated to do so. The lack of skills and competencies in requesting certain exams,

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based on Thompson et al. (2011), can be fatal for patients and limiting for the clinical routine of the veterinarian. According to the syllabi examined here, several imaging techniques are not proposed in undergraduate education. When they are included, the bibliographic references indicate that many are not covered in the recommended readings for the development of the discipline.

4 Final Considerations

Based on the research conducted in the Veterinary Medicine course at the Universidade Estadual do Maranhão in São Luís, Maranhão, it can be concluded that the data obtained provide a qualified analysis of the teaching of Laboratory Animal Science and Diagnostic Imaging at the institution. By investigating and analyzing the Course Pedagogical Projects (PPCs) and the syllabi of these components over the defined period, the study highlighted the adopted curriculum structure and existing formative gaps, contributing to a broader understanding of the preparation offered to future veterinarians.

The results suggest that future veterinarians may prioritize certain areas of diagnostic imaging, namely: X-ray (RX) and Ultrasonography (US), with other areas — such as computed tomography, Magnetic Resonance Imaging (MRI), endoscopy, echocardiography, etc. — being relegated to the background. Following this reasoning, what has been omitted since the time of teaching could extend to professional practice and training. The tendency is that only a few graduates from this institution will work beyond RX and US.

The results also suggest that graduates from this institution do not pursue Laboratory Animal Science (CAL) simply because they are entirely unaware of its existence, as there has been no regular teaching on this topic, which was confirmed in the studied period. Formally and informally, it is known that this has never been the case since the foundation of the course. This situation is considered serious, as it contradicts RN 49/2021 of CONCEA.

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Finally, it is hoped that the results presented in this paper can contribute to the training of future veterinarians and Veterinary Medicine professors graduating from the Universidade Estadual do Maranhão.

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