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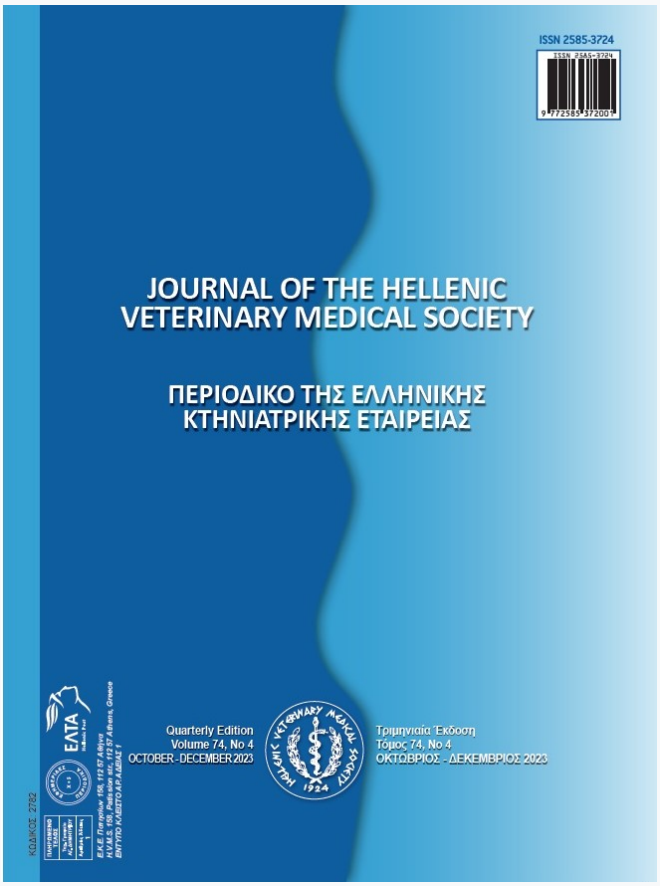

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Review article
Ανασκόπηση

Abnormal twins: dog and cat

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ABSTRACT: A survey of congenital malformations in dog and cat relating to their abnormal embryonic twinning was carried out. According to the degree, sites and angle of fusion, they have various external variation and are classified as free asymmetric, conjoined symmetric or asymmetric twins and unequal conjoined twins (heteropagus or parasitic twins). This manuscript aims to describe and summarize these defects. Among the recorded duplications in dog, a number of common defects relates to cephalothoracopagus phenotype whereas some cases of caudal duplication or parasitic twins have been surveyed. Among the recorded publications in cat, a number of craniofacial duplications have been encountered, whereas, some cases of thoracopagus phenotype have also been described. The pathogenetic mechanisms of this condition, reported in veterinary practice, are discussed. The importance in clinical practice lies in the fact that abnormal embryonic twinning is commonly associated with dystocia. Treatment of the diseased animals is also of veterinary practice consideration. The manuscript finally introduces a framework of an essential national registry for the malformed companion animals.

***Keywords*:** canine; teratology; feline; conjoined twins; congenital malformations

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INTRODUCTION

Abnormalities present at birth considered congenital malformations and comprise defects arising during development in animal organisms (Noden and de Lahunta, 1985). These conditions are observed in various cases of companion animal veterinary practice. Both dog and cat are animal models to evaluate cause-effect relationships between environment and congenital malformations. The record of congenital defects is essential in veterinary medicine and small animal practice. Since, companion animal medicine is established as a major veterinary medical activity, which involves numerous veterinarians, communication between them, is necessary for a registry on the diagnosed cases.

Congenital duplications (conjoined twins, double monsters, or abnormal twinning) are unique and interesting among congenital defects (Hiraga and Dennis, 1993). These duplications form a spectrum of structures which vary from partial duplication to near separation of two individuals. According to the degree, sites and angle of fusion, they have wide external variation (Arthur, 1959) and are classified as free asymmetric, conjoined symmetric or asymmetric twins and unequal conjoined twins (heteropagus or parasitic twins).

However, in the Nomina Embryologica Veterinaria (NEV 2017), a simpler classification of twinning has been suggested. According to the latter, there are the Gemini acardiaci and the Gemini conjucti. The Gemini conjuncti are further subdivided in Gemini conjuncti symmetrici and assymetrici (Table 1).

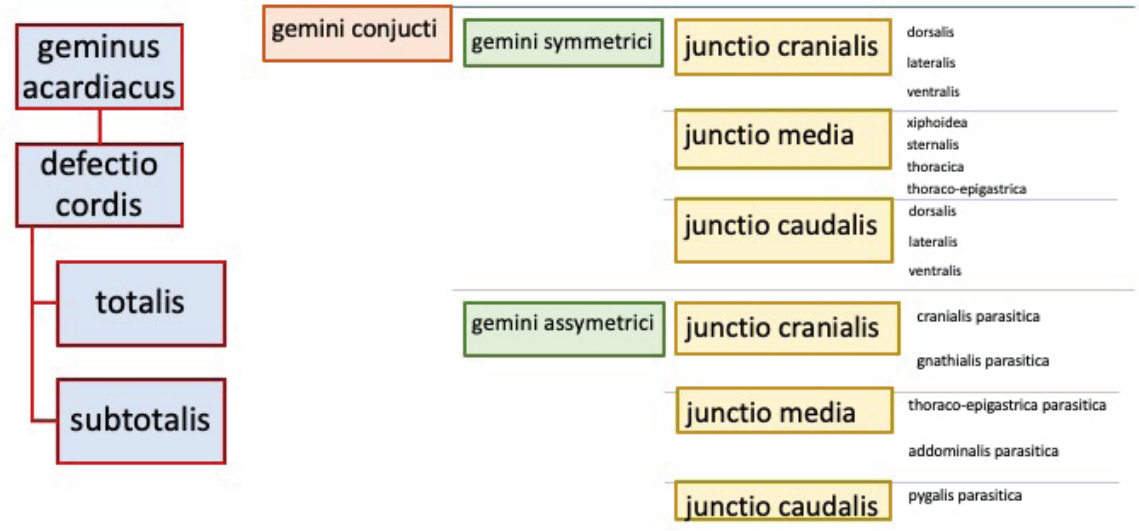
In order to facilitate the quotation of various malformations a concise terminology must be mentioned. The term pagus means fixed or fused or united and always follows an anatomical term such as omphalo- (umbilicus), thoraco- (thorax), cephalo- (head), ischio- (hip), cranio- (skull), rachi- (spine), pygo- (rump), para- (side).The only other terms usually needed are the numeric prefixes di-, tri-, and tetra- (two, three, and four) and terms for anatomical structures that may be united, e.g., -prosopus (face), -cephalus (head), -brachius (fore limb), and -pus (hind limb), as well as an occasional compound term used to describe twins intermediate between the standard types (e.g., prosopothoracopagus).

Cephalic parapagia is classified as diprosopia or dicephalia (Hiraga and Dennis,1993). Diprosopus twinning refers to a single body and a single head, showing a spectrum of duplications of craniofacial structures with great variability in their site of union and degree of organ sharing. In the most extreme form of diprosopus twinning, two complete faces/snouts are seen, whereas the mildest form may present only isolated duplication of the nose. Dicephalus refers to two totally separated heads.

Autosite and parasite monsters consist of two components of very unequal development, the one (autosite) being normal or nearly so, and the other (parasite) quite incomplete and attached to the first as a dependent growth, usually adhering to some point upon the ventral side.

The International Committee on Veterinary Em-

Table 1: The classification of abnormal twins according to Nomina Embryologica Veterinaria



bryological Nomenclature (2017) provided a clear and relatively precise classification of conjoined twins in Nomina Embryologica Veterinaria (NEV). According to the N.E.V., the malformed conjoined twins are subdivided in two main categories namely symmetric and asymmetric. Following, both the symmetric and asymmetric twins are classified into three general conjunction groups: cranial, medial, and caudal conjunction. Classically, the conjoined twins can be divided into dorsal, lateral and ventral conjunction types. The rostral (cranial) ventral conjunction comprises the cephalopagus, thoracopagus and omphalopagus. The caudal ventral conjunction comprises the ileoischiopagus, whereas the lateral cranial conjunction the parapagus diprosopus and parapagus dicephalus (Table 1). When the twins are joined dorsally, they are the craniopagus, rachipagus and pygopagus.

Canine twins

Caudal duplication or parasitic twins? This is the first group of abnormal twinning recorded in dogs. The cases which are quoted in Table 2, do not answer exactly this question. However, these case reports marginally, are considered caudal duplications, even though some of them have features of asymmetric twinning. The other group of malformations of the cephalothoracopagus/symmetric conjoined phenotype are quoted in table 3.

A brief description of the canine cases is given along with other information in the Tables 2 and 3; some indicative malformations of abnormal canine twins are depicted in Figure 1.

Feline twins

In the cat, craniofacial-duplication is a common malformation of abnormal embryonic twining. In Table 4 the feline cases of cranio-facial duplication are quoted. The duplications are mainly subdivided in dicephalus and diprosopus phenotype. The other pool of conditions which occur in cat, comprises two groups. The first is composed of twins exhibiting caudal duplication (Table 5) and the second is composed of twins of the cephalothoraco omphalopagus phenotype (Table 6). Finally, Wilder (1908) reported on a parasitic thoracopagus kitten, without quoting further information regarding the morphology of the malformed fetuses.

A brief description of the feline cases is given along with other information in the Tables 4 to 6; some indicative malformations of abnormal feline twins are depicted in Figure 1.

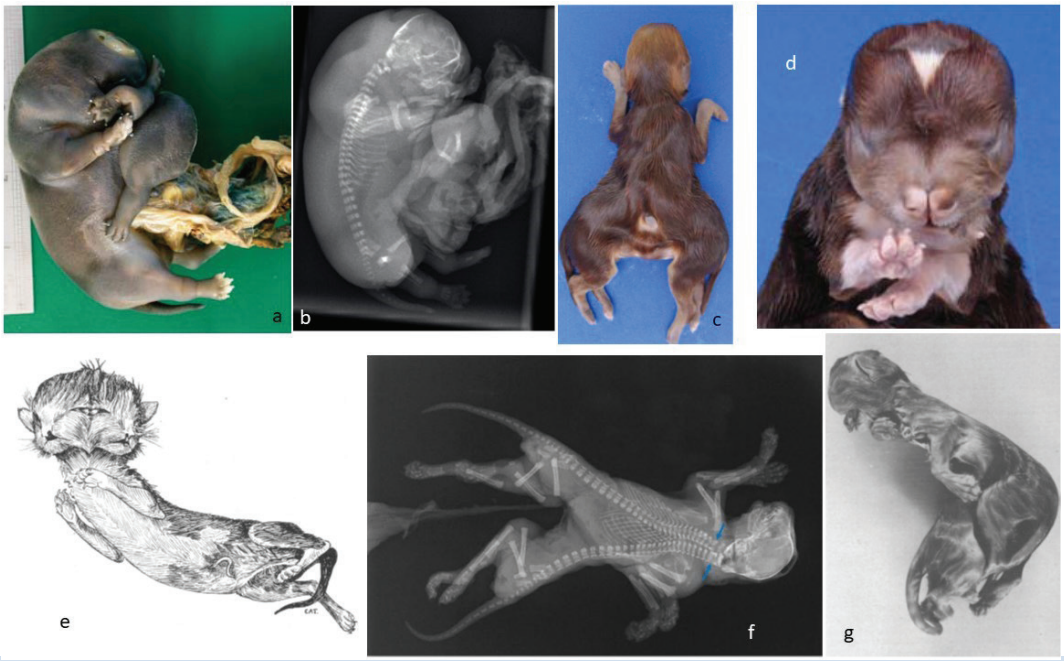


Figure 1. Various malformations of abnormal embryonic twins in dog and cat. a: canine twins with the autosite on the left and the parasite on the right (House et al. 2012). b: Lateral radiograph of the canine twins with the autosite on the left and the parasite on the right. The parasite has no visible vertebral column (House et al. 2012). c: Monocephalus thoracopagus bibrachius tetrapus puppy (Oviedo et al. 2008). d: Partial diprosopia of Monocephalus thoracopagus tetrabrachius tetrapus puppy (Oviedo et al. 2008). e: Diprosopus triophthalmus kitten (Pires de Lima 1918). f: Cephalo-thoraco-omphalopagus deradelphous kitten (Rodrigues et al. 2021). g: Syncephalus Cephalothoracopagus kitten (Sekeles 1985).

Table 2: Brief descriptions of malformations of caudal duplication in dog

Breed/Sex	Classification	Brief description	Reference
♂	Caudal duplication	Malformation with supernumerary limb projecting from the perineum and lack of tail. The extra limb had the major axis turned about (ca 180°) and, compared with the two normal limbs, showed a shorter length. Other external features included atresia ani, double penis and absence of scrotal sacs. Reflection of the skin showed absence of ectopical testes and two completely developed penises but rejoined at the glans level. Internal examination showed absence of omentum, dilation of the intestinal terminal segment, containing meconium, and two urinary bladders. The large intestine was duplicated and fused terminally with an imperforate anus, leading to intestinal obstruction and dilatation. The urinary system consisted of one normal kidney and the other showing hydronephrosis and dilated ureter and two completely separated urinary bladders, close together at the level of the neck, not leading to the respective urethra. The supernumerary limb, arising from the right pelvic region, was underdeveloped and tridactyl. The supernumerary limb showed absence of fibula and tibia and presence of three metatarsal bones and phalanges.	Mazzulo et al 2007
German shepherd mix/♂	Caudal duplication sex reversal	The left hind limb had severe joint contractures, with the presence of what appeared to be a second paw. The dog also had two sets of external genitalia of opposite phenotypic sex; a complete male reproductive tract with a left retained testicle and a right descended testicle, as well as rudimentary female external genitalia including a hypoplastic vulva with a blind-end vagina and a hypertrophied clitoris. The female genitalia were located on the proximal posterior third of the deformed limb. Following amputation of the hind limb, gross pathologic analysis revealed a duplication of the fibula, tarsal, and metatarsal bones, digits, and appendices. The supernumerary structures and female genitalia were concluded to represent a parasitic twin. As conjoined or parasitic twinning of non-identical twins is thought to be impossible, the presence of genitalia of opposite phenotypic sex appeared paradoxical. Polymerase chain reaction analyses were therefore performed to determine the genotypic sex of both animals, which revealed the presence of the Y chromosome in all tissues, including the female genitalia.	Paquet et al 2011
American Staffordshire Terrier /♂		Imaging (radiographs, abdominal ultrasound, and computed tomography with excretory urogram) showed a supernumerary pelvis with associated pelvic limbs, no osseous continuity with the primary spinal column, a colonic diverticulum extending to the supernumerary pelvis, an enlarged left kidney with a ureter connecting to a single bladder, right renal aplasia, a single descended testicle in the primary scrotum, an intra-abdominal cryptorchid testicle, and two unidentifiable soft tissue masses. At surgery, a single ileum was present with a primary and accessory cecum and colon and the accessory colon entering the supernumerary pelvis. The accessory cecum and colon, right kidney, two unknown soft tissue masses, and the single descended testicle were removed. The right kidney had a ureter that anastomosed with the accessory colon at its entry into the supernumerary pelvis. The supernumerary pelvis and hind limbs were not removed.	Grimes et al 2018
♂		The puppy presented congenital duplication of the pelvis and of the urogenital organs. The urinary bladder and urethra were completely duplicated. There were three tails with no bony structures in two of them, and two penises. Two kidneys were observed, the right being normal whereas the left being smaller and exhibiting mild hydronephrosis. The left kidney had a ureter draining into a separated bladder.	Marmol et al 2021

Shih Tzu/ ♀	Malformation with a rigid mass, which resembled two hindlimbs in the pelvic region. Radiographic assessment showed two extra hindlimbs stemmed from malformed pelvic bones and were shorter than normal limbs. Both extra acetabulums were detected on the hemipelvis, and two extra coxofemoral joints were found perpendicular to the regular hip joints in the caudal direction. Also, two vulvas and two anuses were seen, but only one vulva and anus were functional.	Amanollahi et al 2023

Table 3: Cases of symmetric conjoined twins in dog

Breed/Sex	Classification	Brief description	Reference
♀	Single head, double body	The body fusion here extended to the umbilicus. It had a single umbilical cord, and a 'compound' liver. The stomach and the first two-thirds of the small intestine were single, then the intestine bifurcated and was double to the end. The urogenital systems were independent and complete for each body. There were two perfect sets of lungs. The hearts were fused. There was no trace of duplicity in the head although the necks were distinct. The thorax was compound, the sternum and ventral ends of the ribs of each side being so reflected and fused with the corresponding parts of the other as to form one cavity with forty-eight ribs. There were four complete anterior appendages, and the posterior appendages and pelvises were distinct and perfect.	Pilcher 1880
♂	Cephalothoracopagus Monosymmetros	15 cm long with a conspicuously blunt head and 8 legs. Urinary and genital organs were properly formed on both sides.	Engel 1931
♀	Craniothoracopagus Monocephalus thoracopagus tetrabrachius	There were two distinct and separate pelvises, four hind limbs, two tails, two umbilici and partial joining of the abdomen. X-ray examination revealed two distinct spines resulting from two lateral and an apparently fused medial occipital condyle. In addition, the spinal column showed scoliosis. There was a single but enlarged heart, which had two aortae emanating from the left ventricle, and there were two caudal vena cavae returning to the right atrium. One trachea was present which inserted into partially duplicated and enlarged lungs. There was a single sternum but two sets of rib cages. There was a duplication of the spleen, pancreas and the intestines while there was an anastomosis of the two sets of ilea at the midline. The two stomachs were fused along the lesser curvature while the liver appeared larger than normal and extensive. There were four kidneys, The pelvic bones, bladder and genital systems were duplicated.	Nottidge et al 2007
♂	Monocephalus thoracopagus tetrabrachius tetrapus	Partial diprosopia, cleft palate, four fore and four hind limbs	Oviedo TS et al 2008
♀	Monocephalus thoracopagus bibrachius tetrapus	Two fore limbs, total symmetrical duplication of the pelvis, hind limbs, tail and umbilical cords	Oviedo TS et al 2008
♀	Monocephalus rachipagus tribrachius tetrapus	External findings showed a single head. The thorax displayed a caudal duplication arising from the lumbosacral region. The puppy had three upper limbs, a right and left, and a third limb in the dorsal region where the bifurcation began. The subsequent caudal duplication appeared symmetrical with four hind limbs and two tails. Necropsy revealed internal abnormalities consisting of a complete duplication of the urogenital system and a duplication of the large intestines arising from a bifurcation of the caudal ileum.	Pino et al 2016

Lhasa Apso / ♀	Cephalothoracopagus	The twins were joined from the head to the umbilicus. There were two umbilical cords. They had three pentadactyl thoracic limbs and four pelvic limbs, two of which were pentadactyl and two had four toes. Two of the thoracic limbs had a normal ventral position, but the third was situated dorsally and was larger than the others. The palate had a complete medial cleft. The vertebral column showed the cervical segment with partially duplicated vertebrae and a bifurcation in the seventh vertebra. There was no sternum, and each had thirteen pairs of ribs. Brain formed by one cerebrum with two apparently normal hemispheres, two cerebellums and two brainstems, and entirely duplicated spinal cord. The digestive tube had duplicated segments after the caecum (one caecum, two colons, two rectums and two anuses). Only one spleen was present in the left twin. The urinary system was entirely duplicated, but the right twin had hypoplastic kidneys and bifid renal pelvises. The kidneys of the left twin, although developed, also had bifid renal pelvises. There were two complete reproductive systems.	Moura et al 2017

Table 4: Brief description of various malformations of craniofacial duplication in cat

Breed/Sex	Classification	Brief description	Reference
	Partial diprosopia	Crown Rump Length (CRL) 34cm	Wilder 1908
♀	Dicephalia	Malformation with two distinct umbilical cords. The urogenital organs are complete for each body. The oesophagus and stomach are single, and are apparently of normal size arid structure. The trachea, heart, and lungs are also apparently normal for a single individual, except that the heart is rather larger than would be expected in a kitten of this age.	Reese 1911
♂	Diprosopus triophthalmus	The monster has two ears, three eyes, the medial one being constituted by two coalescent ocular globes with two corneas, united along a vertical line; two noses, each with two nostrils, the internal ones only being permeable; two mouths, each with its own tongue.	Pires de Lima 1918
♀	Diprosopia	Malformation with single head, one pair of ears, two complete faces, with two mouths, two noses properly formed, and four eyes, two of which were situated in a common orbit “between the two noses, but had completely separate slits and eyelids”	Bissonnete TH 1933
	Partial dicephalia	Besides the three eyes, the kitten had two noses, two mouth openings, but only two normally placed ears. The two mouth cavities coalesced posteriorly, and the two tongues were fused at their bases.	Ellinger et al 1950
	Diprosopus	Double face, three eyes, two ears, two mouths	Antin 1956
	Partial diprosopia	The anterior part of the head had the form of two apparently equal snouts. In addition to this median eye a pair of normal eyes was present. The angle of divergence of the snouts was approximately 62^{o}	Gaunt 1957
	Diprosopia	Three eyes, cheilopalatoschisis	Gerisch & Wilkens 1976
♀	Diprosopia	CRL 14cm, weight 119 gr. The facial bones as well as the frontal and parietal bones were duplicated. Two well developed lips and a mouth in each face, as well as nostrils and external nares were observed. Only two normal eyes were present. In the midline, where the two faces were fused, a single empty orbit was present, surrounded by eyelids.	Sekeles et al 1985
	Diprosopia	Three eyes	Luerssen 1986
	Diprosopia	All facial components were completely duplicated. Fusion of the skulls had occurred in the temporal region; a single ear was present at the site of fusion. Additional defects were a cleft lip in one face and cleft palates in both faces. The cerebral hemispheres and arterior portions of the brain stem were completely duplicated, whereas the cerebellum and caudal brain stem were partially duplicated.	Aharon DC et al 1986

♀	Diprosopus	In the head, two snouts, three eyes and two pinnae were present. The mandible was single and immobile because labial skin of both upper lips and single lower lip was partly fused. Two incomplete oral cavities were present and the two tongues were joined at their base. The brain was duplicated in part. In the cranium only occipital and temporal bones were normal, the basisphenoid was bifurcated and the remaining bones were duplicated.	Camon et al[a] 1990
♂	Dicephalus	The animal exhibited two heads joined at the level of an anomalous medial exoccipital bone. Two brains and two foramina magna were present. The vertebral column was single but the cranial cervical vertebrae (C2 to C5) had doubled bodies. Cervical rachischisis with myeloschisis were associated defects. Two nasopharyngeal and oropharyngeal cavities converged caudally into a single laryngopharynx. The esophagus, larynx and trachea were single. Duplication of the tongue and hyoid apparatus was present. Palatoschisis affected both oral cavities. Hypoplasia of the anatomical structures in the medial aspects of both heads was observed. Microphthalmia was also observed in both medial eyes.	Camon et al[b] 1990; Camon et al 1992
	Dicephalus		Hamzé et al 2009
	Diprosopus	The head of the dead neonate was larger than normal, and had two faces with two ears, four eyes, two noses, two oral cavities, and two tongues. Cleft palate was also found in the left oral cavity.	Mizutani et al 2009
♀	Diprosopus	The kitten with CRL 13cm and weight 120 gr had symmetrical duplication of head involving almost complete face. There was fusion of both skulls in the temporal region. There were two sets of fully developed lips, oral cavity, eyes and external nares. There was absence of cleft in the hard palate inside both oral cavities However, there were only two ears situated on the outer side of each face.	Singh AK et al 2019

Table 5: Brief descriptions of various malformations of caudal duplication in cat

Breed/Sex	Classification	Brief description	Reference
	Caudal duplication	The cat had two thoracic and four pelvic appendages. The rectum, caecum, and caudal part of the ileum were double; the rest of the intestine, the stomach, the trachea, the thyroid, and the heart were single. The right kidney was in the right side of the body, the left kidney in the left side. There were two aortic arches, two pancreas, and two livers, the right liver being incomplete. The right lung was rudimentary.	Gurlt 1832
	Caudal duplication	The division took place at the base of the tail, so that there were two normal tails and four normal hind legs.	Dareste 1852
♀	Caudal duplication	The head presented two anterior nares but no oral aperture. Four hind legs and a malformation of left eye and submaxillary region. In the gross specimen the duplication of the caudal portion of the body started in the lumbar region. Both parts were equally developed, both sets of pelvic limbs and both tails were apparently large. The duplication started at the second lumbar vertebra. One heart, one pair of lungs in the thoracic cavity were observed. In the abdominal cavity there were one spleen, one stomach, one small intestine and one pancreas. The ileum terminated between two ceca, each of which continued as colon and rectum to its respective anal orifice. There was but one pair of kidneys, one for each body. There were two bladders, each of which received the ureter from the kidney of its side. There was but one ovary, uterine tube and vagina in each body.	Radasch 1912
	dipygus	One head, one set of thoracic limbs, two sets of pelvic limbs, with some doubling of the trunk	Antin 1956

	monocephalus dipygus parapagus	Grossly, the kitten demonstrated a small bifurcation in the lower mandible and an extensive cleft palate. The upper body as far as the last rib appeared normal but the bifurcation of the body then occurred, resulting in two identically paired hind limbs and tail sections, each facing the other rather than in parallel.	Seavers 2009

Table 6: Brief descriptions of cephalothoracopagus phenotype in cat

Breed/Sex	Classification	Brief description	Reference
♀	Cephalothoracopagus	The umbilical cord was double consisting of four umbilical arteries and two umbilical veins. The head og the specimen possessed three external ears; two of which symmetrical. The third held in intermediate position. The two fore limbs on the right side were in the usual position, while the right fore limb of the left monster had unusual positioning. There were double cerebellum, pons, medulla and spinal cord. One oesophagus and stomach were observed. After pylorus, bifurcation of the intestinal tube were observed. The other abdominal viscera were double.	McIntosh WC 1868
♂	Cephalothoracopagus syncephalus	There were two forelimbs. Each set of hindquarters of the double kitten was equipped with a vertebral column, tail and two hind limbs, all of which seemed, of normal appearance. The two vertebral columns were fused at the mid-cervical area; cranially only a single column was present. One of the spinal columns (left) was curved normally for a newborn kitten but its twin (right) showed a marked lordosis in the thoracic area and so the latter rump appeared to be parasitic on the first. Cleft palate in the head. The thoracic cavity contained only a single set of organs. The descending aorta bifurcated at the level of the diaphragm into two abdominal aortae. The contents of the common abdominal cavity contained a single set of organs of the digestive tract as far the level of the ascending colon which here bifurcated	Sekeles 1985
♀	Deradelphous cephalothoracopagus	The twins had two nearly opposite fused bodies, with the head larger than normal. A mandibular cleft, probably due to the two lateral mandibles of each subject, was visible and two separate tongues occupied the enlarged oral cavity. Thorax and abdomen appeared to be unique, more extensive than normal kittens and with two umbilical cords arising from a single navel.Two sets of forelimbs, abnormally spatial orientated, were seen. The two pelves were distinct and separated with the own hind limbs and one tail each. Internal examination revealed the presence of single but enlarged liver and heart. The gastro-intestinal apparatus showed two tongues joined to a single hyoid bone. A single oesophagus was inserted into a single stomach and the intestine appeared unique until the ileo-caecal region, where two colons merged each ending in their own anal region, producing a Y figure. Two tracheas were fused and inserted into partially duplicated lungs. Kidneys were duplicated.	Mazzullo et al 2009
♀	Cephalo-thoraco-omphalopagus deradelphous	The twins had two anatomically well-formed genitourinary systems, each with a pair of kidneys and ureters, urinary bladder, urethra, a pair of ovaries, uterus, vagina, and vulva. The digestive system comprised a single esophagus, stomach, small intestine, and cecum. The bifurcation started from the ileocecal region, originating from two distinct large intestines that ended in two distinct rectums and anuses. The liver, pancreas, and spleen were also unique, with normal macroscopic characteristics.	Rodrigues et al 2021

DISCUSSION

Numerous classifications of conjoined twins are available, based on anatomy, site of union, symmetry level of twins and embryological development. Abnormalities in the anatomy of conjoined twins arise during prenatal development. The implications of these abnormalities can lead to organ dysfunction, organ failure or even death. Genetic and environmental factors are thought to be main causes of the development of conjoined twins. At present, two hypotheses (partial fission versus secondary fusion) are used to explain the mechanisms behind the formation of conjoined twins (Boer et al., 2019). Although both theories are postulated throughout literature, controversies remain existing. The fission theory, which assumes that conjoined twins originate around the primitive streak stage of embryonic development, is more postulated in textbooks, whereas the model of secondary fusion is a widely accepted premise in current research papers (Spencer, 2000a, b). In addition to the fission and fusion theories, a third scenario to explain conjoined twins may be the initial "crowding and thereby duplication of morphogenetic potent primordial" (Boer et al.,2019). The latter authors proposed that initial duplication of axially located morphogenetic potent primordial in one inner cell mass is the initiating factor in the formation of ventrally, laterally and caudally conjoined twins. The dorsally conjoined twins, the craniopagus, rachipagus, and pygopagus, not only are the easiest to explain, but also provide the most convincing evidence for the ''fusion''theory (Spencer 2000a,b).

Anatomical duplications appear more commonly to involve the caudal part of the body in dogs. In cats, duplications affected more frequently the cranial portion of the body. In the group of symmetric conjoined twins (Tables 3 and 6), the puppies and kittens respectively, usually are joined mainly across the heads and/or the thoraxes, and/or the abdomens and presumably possess two pairs of fore limbs and two pairs of hind limbs. However, we must point out, that the description and classification of these malformations is many times vague and ambiguous.

The incidence of conjoined twinning in the dog is unknown but the paucity of reported cases in the literature suggests that it is very rare.

On the other hand, Pia (1971), recorded a total of 588 cases of feline congenital malformations of which 89 cases were duplications. In fact, from 89 feline conjoined twins, Pia (1971) found 53 caudal symmetrical duplications, 29 cranial symmetrical duplications and 7 asymmetrical double monsters, diprosopia being the most frequently reported anterior duplication. Saperstein et al. (1976), in another review relating to the feline congenital malformations, reported mainly on craniofacial duplications.

Regarding the developmental mechanisms contributing to the abnormal twinning, it seems that duplication of the naso-facial structures has been attributed to duplication of the neural crest derivatives. Derivatives of the neural crest are supposed to be partially or totally duplicated when there is an initial duplication of the notochord leading to two neural plates and subsequently duplicated neural crests (Carles et al., 1995). Among the fifteen feline craniofacial duplications surveyed, only four dicephaluses were recorded; the rest were various aspects of diprosopus.

The cause of asymmetry between the autosite and the parasite is thought to be vascular compromise of the parasite, leading to dependence on collateral circulation from the autosite. Ischemic atrophy of the parasite is a result of this circulatory compromise. (Grimes et al., 2018).

Regarding the sex of twins, in the cases which were surveyed in the present review, variations were observed according to the group of malformations. In the group of feline craniofacial duplications, two males and five females were recorded. In the cases of feline cephalothoracopagus phenotype, three females and one male were registered.

In the dog, among the seven cases of conjoined twins, which were surveyed, five females and two males were identified. On the other hand, among the cases of canine caudal duplication, four males and one female were detected. In the cat, among the abnormal twins with craniofacial duplication, five females and two males were recorded. The abnormal twinning of kittens and puppies has been occurred independently of the breed.

Detailed anatomical studies of congenital duplications are rare descriptions of external features or minimal dissections have occasionally been made. Anatomical descriptions of these malformations can only provide some indications of possible etiologies.

Identification of etiological agents or causative mechanismsis extremely difficult, particularly in spontaneous animal malformations, because defects occur and become evident sometime after exposure to

the teratologicalagent, and usually adequate records are not available. However, an attentive analysis of the anomalous anatomy showed by malformed individuals, and a consideration of the underlying morphogenetic processes, can be helpful for a better understanding of congenital malformations. (Camon, 1992).

In conclusion, the establishment of a national registry for animal malformations is crucial. Therefore, we present a few aspects to a successful founding of such registry:

Collaboration: Encourage veterinarians to collaborate with relevant authorities, such as the Hellenic Veterinary Medical Association, government agencies, and research institutions. Collaboration will help ensure the registry's success by leveraging expertise, resources, and data sharing.

Standardization: Advocate for standardized data collection methods, terminology, and classification systems. This will enable accurate and consistent reporting of malformations, facilitating data analysis and comparisons across different cases.

Confidentiality and Privacy: Emphasize the importance of maintaining confidentiality and privacy when collecting and storing data. Veterinarians should obtain informed consent from animal owners and adhere to relevant data protection laws and regulations.

Comprehensive Data Collection: Encourage veterinarians to gather comprehensive data on each malformation case, including animal species, breed, age, sex, geographic location, clinical presentation, genetic information (if available), and any known exposure to potential teratogens. The more data collected the better insights can be gained.

Longitudinal Tracking: Establish a mechanism to track malformation cases longitudinally. This will enable monitoring of trends over time, identification of potential risk factors, and evaluation of the effectiveness of preventive measures.

Reporting and Analysis: Advise veterinarians to report malformation cases to the registry in a timely manner. Encourage the analysis of collected data to identify patterns, geographical clusters, potential causes, and emerging trends. Regular reporting and analysis can provide valuable information for research, policy-making, and public awareness.

Educational Outreach: Promote educational initiatives for veterinarians, pet owners, and the general public regarding the importance of reporting malformations and the role of the registry. Increasing awareness can encourage active participation and contribute to a more comprehensive and accurate database.

Research Collaboration: Encourage collaboration with academic institutions and researchers interested in studying animal malformations. Collaborative research efforts can lead to a better understanding of the causes, prevention, and treatment of malformations, benefiting both animal health and human health (as some animal malformations may have underlying environmental or genetic factors that could also affect human health).

Regular Updates: Ensure that the registry is regularly updated, maintained, and accessible to relevant stakeholders. Periodic reports summarizing the findings and trends can be disseminated to veterinarians, researchers, and policymakers to inform decision-making and improve animal health outcomes.

Continuous Improvement: Encourage veterinarians to seek feedback from users of the registry and make necessary improvements based on their input. Continuously evaluating and enhancing the registry's functionality and usability will help maximize its impact.

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