动物科学

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不同大小草鱼血液学指标研究*

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摘要 :为讨论体长(*L*)对草鱼(*Mylopharyngodon piceus*)血液学指标的影响,采集体长范围为 9.4 ~ 30.7 cm 的草鱼 61 尾,按体长分为 5 组,分别测定各组鱼体内红细胞的数量、长径、短径、面积和血红蛋白含量(*Hb*)。结果表明,草鱼红细胞的数量、长径、短径、面积和血红蛋白含量的平均值分别为 2.33×10^9 个 · mL^{-1}、14.3 μm、9.2 μm、96.1 μm^2 和 83.77 mg · mL^{-1} ;草鱼的血红蛋白含量随体长增加而增加,二者之间的关系可以描述为方程 $Hb = 1.47L + 55.1$ ($n = 61$, $r^2 = 0.307$, $p < 0.01$),而红细胞数量、长径、短径和面积随体长增加均无显著变化 ;红细胞数量和长径均分别与血红蛋白含量显著正相关($p < 0.05$),红细胞短径与红细胞数量显著负相关($p < 0.05$)。结果提示草鱼血液的载氧能力随体长增加而增强,血红蛋白含量越高,红细胞数量越多,红细胞形状越趋于椭圆。

关键词 :草鱼 ;血液学指标 ;体长 ;血红蛋白 ;红细胞数量
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血液指标是鱼类重要的生理指标之一[1],被广泛用于评价鱼类的营养健康状况和对环境的反应[2]。鱼类血液中含有红细胞、白细胞、单核细胞、粒细胞和淋巴细胞等,其中红细胞最多[3]。红细胞上含有血红蛋白,其主要功能是运载氧气,因此红细胞的数量及形态可能与鱼类的血液载氧能力有关。随鱼类个体增大,白肌占肌肉的比例和白肌中的糖原含量增高[4],无氧代谢能力增强[5],因而个体总代谢率增高[6],提示鱼类的血液学指标随个体生长可能发生变化。有限的资料已发现鳗鲡(*Anguilla japonica*)和南方鲇(*Silurus meridionalis*)随个体增大,血红蛋白含量增加[7-8],但需要更多物种的研究资料加以验证。

草鱼(*Mylopharyngodon piceus*)属于鲤形目(Cypriniformes)、鲤科(Cyprindiae)、草鱼属(*Mylopharyngodon*),广泛分布于各地水域,是中国淡水养殖的 4 大家鱼之一。有关该种鱼的血液学研究仅有少量报道[9-12]。该种鱼血液指标随个体增长的变化特征尚需研究。本研究以草鱼为对象,测定随体长增大过程中草鱼血液的红细胞数量、长径、短径、面积和血红蛋白含量等血液指标的变化特征,为研究该种鱼的载氧能力随生长的变化规律提供基础资料。

1 材料和方法

1.1 驯化条件

实验所用草鱼购于重庆市北碚区歇马鱼场,选 1 龄以内健康草鱼在实验室水族箱中驯化 2 周。驯化饲料为商业草鱼饲料,每天 18: 00 时投喂 1 次,投喂量为鱼体体重的 1%。驯化期间采用曝气 24 h 以上的自来水,每升水体溶氧量大于 7 mg,水温控制在(25 ±1) ℃。

1.2 实验方法

采用含量为 0.04 g · L^{-1} 的氟化钠、草酸钾混合液作为抗凝剂(氟化钠与草酸钾质量比为 1: 3),在取样用注射器和离心管中各加入 0.1 mL,使之分散于内壁,70 ℃烘干备用。用 0.1 g · L^{-1} 的 MS222 将草鱼麻醉 4 min,测定体长(*L*)、体重(*W*),体长精确到 0.1 cm,体重精确到 0.1 g。经测定,实验鱼体长范围为 9.4 ~ 30.7 cm,体重范围为 16.2 ~ 490.8 g。按体长分为 5 组,分别为 1 组(9.4 ~ 12.8 cm)、2 组(14.6 ~ 17.5 cm)、3 组(17.8 ~ 19.9 cm)、4 组(19.8 ~ 22.8 cm)和 5 组(22.9 ~ 30.7 cm)。用注射器从尾动(静)脉取血,血样取出后,迅速注入抗凝的离心管内备用,整个采血程控制在 1 min 以内[13]。血红蛋白含量(Haemoglobin content,*Hb*)采用碱化比色法测定[14] ;红细胞计数(Red blood cell,*RBC*)用 0.6% 生理盐水将血液稀释 200 倍,用 Neubarner 计数板在显微镜下计数[15]。单位红细胞血红蛋白含量用血红蛋白含量除以红细胞数得到。红细胞长径、短径和面积采用 40 倍镜下随机取视野内 10 个红细胞测定其平均值 ;血涂片采用‘姬萨姆 + 瑞士’染液染色[16],100 倍油镜下拍照。

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1.3 数据处理方法

采用 Excel2003 和 SPSS11.5 软件进行数据整理及统计分析。各组间比较采用单因素方差分析和 LSD 检验,显著性水平为 0.05,有关数据用"平均值 ± 标准误"来表示。

2 结果

从表 1 可见,随体长增加,红细胞数量、长径、短径和面积均无显著变化。血红蛋白含量随体长增加而显著增高,体长组 2、3、4 和 5 的血红蛋白含量显著高于体长组 1 的血红蛋白含量($p < 0.05$),二者之间的关系可以描述为方程 $Hb = 1.47L + 55.1$ ($n = 61$, $r^2 = 0.307$, $p < 0.01$)(图 1)。经相关性分析可知,红细胞数量与血红蛋白含量显著正相关($p < 0.05$, $r^2 = 0.083$),红细胞长径与血红蛋白含量显著正相关($p < 0.05$, $r^2 = 0.099$),红细胞短径与红细胞数量显著负相关($p < 0.05$, $r^2 = 0.074$)。单位红细胞血红蛋白含量在各组间无显著差异。各个体长组代表性血涂片的红细胞形状见封三彩图 2。

表 1　不同体长草鱼的血液学指标

Tab. 1　Haematological parameters in *Mylopharyngodon piceus* of different body length

指标	体长分组				
	1	2	3	4	5
样本数/尾	7	15	11	10	18
体长/cm	10.9 ± 0.5	16.0 ± 0.3	18.8 ± 0.2	21.8 ± 0.3	24.9 ± 0.5
体重/g	24.7 ± 3.4	74.4 ± 3.8	120.9 ± 3.3	175.5 ± 5.1	264.6 ± 15.2
红细胞数/($\times 10^9$个 · mL^{-1})	1.81 ± 0.24	2.37 ± 0.24	2.20 ± 0.26	2.58 ± 0.80	2.42 ± 0.98
红细胞长径/μm	14.1 ± 0.2	14.4 ± 0.1	14.3 ± 0.2	14.3 ± 0.1	14.4 ± 0.5
红细胞短径/μm	9.0 ± 0.1	8.9 ± 0.2	9.7 ± 0.2	9.3 ± 0.2	9.0 ± 0.1
红细胞面积/μm^2	90.9 ± 1.7	94.3 ± 2.2	99.3 ± 3.1	97.1 ± 2.1	97.3 ± 1.2
血红蛋白含量/(mg · mL^{-1})	63.6 ± 3.7^a	83.5 ± 2.6^b	85.0 ± 3.4^b	85.0 ± 3.6^b	90.4 ± 2.4^b
单位红细胞血红蛋白含量/(mg · mL^{-1})	48.8 ± 17.4	45.4 ± 8.0	54.3 ± 14.3	37.9 ± 6.8	57.8 ± 14.4

注:同一行中带不同上标的数值表示差异显著($p < 0.05$)。

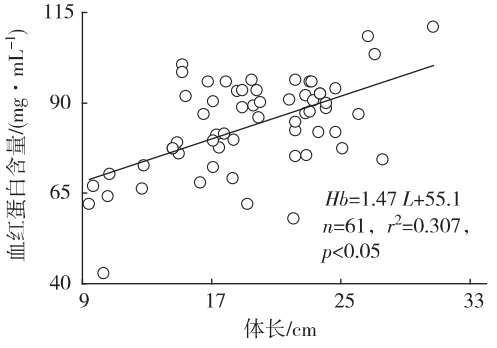

图 1　草鱼体长与血红蛋白含量的关系

Fig. 1　The relationship between body length and hemoglobin content in *Mylopharyngodon piceus*

3 讨论

已有的研究资料中,草鱼红细胞长径范围为 9.7 ~ 14.6 μm,短径范围为 6.3 ~ 10.3 μm,红细胞数量范围为 $1.01 \times 10^9 \sim 3.98 \times 10^9$个 · mL^{-1},血红蛋白含量范围为 21.0 ~ 115.9 mg · mL^{-1}[9,12]。本研究中草鱼的红细胞长径、短径、数量和血红蛋白含量均在已有研究结果范围之内,且变幅均小于已有研究结果,表明本研究取得的结果有较高的精度。

血红蛋白含量反映血液的载氧能力,其含量增高可表征载氧能力增强[17]。本研究中草鱼的血红蛋白含量随体长增加而增高,提示该鱼血液的载氧能力增强。相似的现象也发现于鳗鲡和南方鲇等鱼类[7-8]。本研究中体长与血红蛋白含量的关系提示,草鱼体长每增加 1 cm,血红蛋白含量理论上可增加 1.47 mg · mL^{-1}。已有研究表明,运动能力强的鱼类血红蛋白含量较高[18],由此可以推测大个体草鱼的运动能力可能较强。

本研究中,草鱼血红蛋白含量与红细胞数量显著正相关,提示血红蛋白含量不仅受个体大小的影响,还可能受红细胞数量的影响。红细胞长径与血红蛋白含量显著正相关,而红细胞短径与红细胞数量显著负相关,提示红细胞形状越趋于椭圆,血红蛋白含量越高,红细胞数量越多(封三彩图 2)。鱼类红细胞发育通常经历 3 个阶段即原始阶段、幼稚阶段和成熟阶段,而胞体趋于椭圆,血红蛋白含量增高[3,19-20],本研究结果符合这一规律。

本研究中单位红细胞血红蛋白含量随体长增加无显著变化,提示每个红细胞的载氧能力随生长相对稳定。红细胞的大小随体长增加也无显著变化。Savage 等人[21]提出,快速分化的细胞如红细胞、肝细胞等,它们的大小随个体增大保持恒定;而缓慢分化的细胞如

神经细胞、脂肪细胞等,它们的大小随个体增大而增大。本研究结果支持上述观点,并提示血液组织主要决定于细胞的多少,细胞的大小的作用可能较小。

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Animal Sciences

Effect of Body Length on Haematological Parameters in *Mylopharyngodon piceus*

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Abstract: Sixty-one grass carp (*Mylopharyngodon piceus*) (body length L ranges 9.4 ~ 30.7cm) were sampled and divided into 5 groups according to body length. Red blood cell number (*RBC*), major axis, minor axis, area and serum hemoglobin content (*Hb*) were measured respectively. The results showed that the mean value of *RBC* was $2.33 \times 10^9 mL^{-1}$, major axis was 14.3μm, minor axis was 9.2μm, area was 96.1 μm^2 and *Hb* was $83.77 mgmL^{-1}$. It increased with the increasing L and the relationship between *Hb* and L can be described as $Hb = 1.47L + 55.1$ ($n = 61$, $r^2 = 0.307$, $p < 0.01$). *RBC*, major axis, minor axis and area did not change with the increasing body length. Both *RBC* and major axis were positively correlated with *Hb* ($p < 0.05$), while minor axis was negatively correlated with *RBC* ($p < 0.05$). It indicates that the oxygen carrying capacity of blood of grass carp increases with the increasing body length. The number of the elliptical red blood cell tends to increase as *Hb* and *RBC* increases.

Key words: *Mylopharyngodon piceus*; haematological parameter; body length; hemoglobin; red blood cell

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外刊摘要转载

Long-Term Monitoring of Environmental Change in German Towns through the Use of Lichens as Biological Indicators: Comparison between the Surveys of 1970, 1980, 1985, 1995, 2005 and 2010 in Wetzlar and Giessen

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Abstract: In the years 1970, 1980, 1985, 1995, 2005 and 2010, lichen mapping in the towns of Wetzlar and Giessen in Hesse was performed. The aim was to show the effects of immission load. Despite the application of modified test methods during the study period, the results can still be compared directly because they could be adapted to the requirements of the guidelines of the Association of German Engineers. Even the earlier study results could be interpreted partly within the scope of the guidelines. Parallel to the lichen mapping, comparative examinations of pH on tree bark were carried out. In both towns, the pH of the tree bark has been increasing continuously, presently almost reaching pre-industrial values. The increase was stronger in Wetzlar than in Giessen. In 1970, the lichen vegetation showed a complete depletion. Since then the number of species has risen significantly. This development happened faster and more intensely in Wetzlar. The comparison of the lichen vegetation between 1970 and 2010 also shows an increased existence of species that are favored by hypertrophic air contaminants. In the 2010 survey, some species considered as being promoted by global warming were found for the first time. The increase of the bark pH can be explained by the decreasing acid pollution, primarily SO_2. This is also assumed to be the main cause for the increasing number of lichen species. An explanation for Wetzlar's advantage is that the acid pollutants had been neutralized by a local industrial emittent of lime dust. With the reduction of dust emissions in Wetzlar due to the installation of filters, the bark pH in both towns steadily converged in the reference period. An examination of pre-industrial lichen studies shows that in both towns the original state of lichen vegetation has not been restored yet.

Key words: effects of air pollution; biological measuring technique; VDI guideline; lichens; pH; tree bark; lichen diversity; climate change; long-term monitoring

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